Cardiovascular Health and Occupational Stress in Police Officers

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Dedication

This Dissertation is dedicated to the brave women and men who protect and serve the public every day. To the police force in the Minneapolis-St. Paul Metropolitan Area and across the country, without you, this work would not have been possible.

Abstract

Police officers have a higher incidence of disease and mortality rates when compared to the general population. Few studies have examined the link between lifestyle factors, occupational stressors and physiological dysfunction and how these factors lead to disease progression among police officers. The purpose of this dissertation was to examine the impact of physical fitness, lifestyle and occupational factors, perceived stressors, and sleep quality on various aspects of police officer physical, physiological and psychological health. Specifically, police officers (n = 116) completed several testing methods, both in the lab and field-based settings, assessing physical, physiological and psychological health. The **first aim** was to understand the influence of lifestyle and occupational factors on cardiovascular fitness and autonomic nervous system function among police officers. Not surprisingly, results indicated that officers who engage in regular exercise and have a low body fat also have higher aerobic fitness. There was not a significant relationship between heart rate variability indices and other lifestyle or occupational factors. The **secondary aim** was to examine the effect of perceived work stress on physiological biomarker expression for cardiovascular health. Results indicated that high scores on the Police Occupational Stress Survey (POSS) were related to higher pro-inflammatory cytokines (C-reactive protein (CRP) and tumor necrosis factor alpha (TNFα)). Finally, the purpose of the **third aim** was to examine the effect of sleep quality and shift-work on physiological biomarker expression in association with cardiovascular health. Contrary to what was hypothesized, day-time officers had higher levels of cortisol and total cholesterol expression than middle- or night-shift officers. In conclusion, poor lifestyle choices, unmanaged stressors, and constantly rotating shift schedules may contribute to increased allostatic load which can contribute to early, all-cause mortality among police officers. Future studies are needed that further examine cardiovascular health, sources of perceived stress, and sleep disturbances. Additionally, future research should examine the efficacy of interventions that address psychosocial factors and cardiovascular fitness among police officers.

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Abbreviations

α = alpha

β = beta

γ = gamma

ACh = acetylcholine

ANOVA = analysis of variance

ANS = autonomic nervous system

AR = autoregressive

BF = body fat

BMI = body mass index

Ca^{+2} = calcium ion

CAD = coronary artery disease

cAMP = cyclic adenosine monophosphate

cGMP = cyclic guanosine monophosphate

CRH = corticotropin releasing hormone

CRP = c-reactive protein

Days = day-shift officers

ELISA = enzyme linked immunosorbent assay

ERK = extracellular signal-regulated kinase

FFT = fast-fourier transfer

G = guanosine

GDP = guanosine diphosphate

GTP = guanosine triphosphate

HDL = high-density lipoprotein

HF = high frequency

HPA = hypothalamic pituitary adrenal

HR = heart rate

HRR = heart rate recovery

HRV = heart rate variability

Hz = hertz

IL-6 = interleukin-6

IL-1β = interleukin-1 beta

JNK = c-jun n-terminal kinase

K^+ = potassium ion

LDL = low-density lipoprotein

LF = low frequency

LV = left ventricular

MAPK = mitogen-activate protein kinase

M = muscarinic

MI = myocardial infarction

Mids = middle-shift officers

ms = milliseconds

Nights = night-shift officers

NN = normal to normal

NN50 = number of adjacent normal to normal intervals differing by more than 50 milliseconds

PKA = protein kinase A

pNN50 = percent of normal to normal intervals differing by more than 50 milliseconds compared to the total amount of normal to normal intervals

POSS = police occupational stress survey

PPK = phosphorylate kinase

PSQI = Pittsburgh sleep quality index

PTSD = post-traumatic stress disorder

RHR = resting heart rate

RMSSD = root mean square of successive differences

RR = regular to regular

SAPK = stress-activated protein kinase

SCD = sudden cardiac death

SD = standard deviation

SNS = sympathetic nervous system

TINN = triangular interpolation of NN interval histogram

TNFα = tumor necrosis factor alpha

VLF = very low frequency

VO_{2MAX} = maximal aerobic capacity

CHAPTER

1

INTRODUCTION

CHAPTER ONE: Introduction

Police officers have higher incidence of disease and early mortality from a variety of causes when compared to the general population (Feuer & Rosenman, 1986; Franke, Collins, & Hinz, 1998; Vena, Violanti, Marshall, & Fiedler, 1986; Violanti et al., 2013; Violanti, Vena, & Petralia, 1998). The most recent data indicates that in 2016, 135 police officers were killed in the line of duty, the highest total since 2011. Of these police fatalities, 64 were the result of felonious shootings and 53 were the result of accidents (e.g., automobile collisions, motorcycle accidents, falls). Also, of the 18 officer deaths that resulted from other job-related incidents, 11 of them died from heart attacks while on duty (National Law Enforcement Officers Memorial Fund, 2016). Additionally, in 2015, 50,212 officers were assaulted in the line of duty and most incidents occurred while officers were responding to disturbance calls (U.S. Department of Justice: Federal Bureau of Investigation, 2016).

Officers on duty are more likely to die of sudden cardiac death (SCD) than any other private sector occupation (Calvert, Merling, & Burnett, 1999; Tiesman, Swedler, Konda, & Pollack, 2013). In the police force, the incidence of SCD is 20-60 times higher in high-stress scenarios in comparison with routine/non-emergency job duties, and can occur both while on-duty or within 24-hours post-incident (Varvarigou et al., 2014). According to research by Varvarigou et al. (2014), when researchers compared high-stress scenarios with routine/non-emergency police job duties, they found that of all cases of SCD, 25% had resulted from physical restraints/altercations, 23% from routine/non-emergency activities, 20% from physical training, 12% from suspect pursuits, and the remaining 19% were a combination of duties such as prisoner transport, serving warrants, and medical/rescue operations. It was estimated that though 75% of officer time is spent performing routine/non-emergency tasks (e.g., traffic patrol, serving warrants, transporting prisoners, sedentary administrative duties), 77% of all SCDs were associated with high-stress scenarios/critical incidents (Varvarigou et al, 2014). Specifically, though physical restraints or altercations account for only one percent of officer on-duty time, they represent 25% of SCD incidence. Similarly, suspect pursuits account for only two percent of officer on-duty time, yet are responsible for 23% of SCD events (Varvarigou et al., 2014). Even though older police officers had a higher incidence of SCD than younger officers, the average age of death of these officers was only 47 years-old. Two percent of them were women (Varvarigou et al., 2014).

Higher rates of disease etiologies and several risk factors are indicated with higher rates of SCD in officers. This increased risk of SCD is evidenced by higher rates of endothelial dysfunction (Joseph et al., 2010; Violanti et al., 2006) and atherosclerotic progression (Feuer & Rosenman, 1986; Joseph et al., 2009), hypertension (Pyörälä, Miettinen, Laakso, & Pyörälä, 2000a), coronary heart disease and stroke (Pyörälä, Miettinen, Halonen, Laakso, & Pyörälä, 2000b), various cancers (Forastiere et al., 1994; Gu, Charles, Burchfiel, Andrew, & Violanti, 2011) and higher levels of pro-inflammatory biomarkers (Ramey, Downing, Franke, Perkhounkova, & Alasagheirin, 2011) than those in the general population. These physical and physiological indicators, coupled with high-risk/high-stress scenarios, relate to increased SCD risk among officers.

Consequently, officers also have a higher incidence of mental disorders as evidenced in clinical anxiety, depression, somatization, post-traumatic stress disorder (PTSD), and symptoms of burn-out. Often, incidence of mental disorders are directly tied to negative coping mechanisms and poor stress-management (Gershon, Lin, & Li, 2002; Hartley, Burchfiel, Fekedulegn, Andrew, & Violanti, 2011; Komarovskaya et al., 2011; Liberman et al., 2002; Violanti & Aron, 1995). Police retirees have higher incidence of cardiovascular morbidities exhibited in cardiovascular disease, including hypercholesterolemia, hypertension, overweight and obesity (Ramey, Downing & Franke, 2009). Unfortunately, police retirees also tend to die sooner, with less years spent in retirement, compared to general population retirees (Brandl & Smith, 2013).

The purpose of this dissertation was to examine various aspects of police officer health, including the resulting impacts of physical fitness, lifestyle and occupational factors and stressors, and sleep quality on physical, physiological and psychological health. This paper will begin with an in-depth literature review that first aims to discuss the sympathetic nervous system (SNS) and physiological stress response including pro-inflammatory cytokine production and positive feedback loops between chronic stress and immune system function. Second, the parasympathetic nervous system influence on recovery post-acute stress and heart rate variability (HRV) analysis as a tool to assess autonomic nervous system (ANS) balance will also be summarized. Third, psychosocial factors related to police work will be discussed including shift-work, sleep imbalances, exposure to critical, high-risk incidents and mental health repercussions. Finally, how lifestyle factors such as obesity and physical fitness are linked to ANS balance, cardiovascular health and disease progression will be discussed. The literature review will be followed by descriptive methods, which will detail the study procedures and testing techniques. Then, three projects of original research will be presented in an attempt to fill the research gap surrounding police officer occupational stress, psychosocial factors and cardiovascular health. This dissertation will conclude with overall findings, research implications and finally future directions. Study aims are detailed below.

1.1 Aims and Hypotheses

Study one: Lifestyle and Occupational Variables and Cardiovascular Health in Police Officers

Aim one: To examine the association between lifestyle and occupational variables and their effects on ANS function and cardiovascular health among police officers.

Related hypothesis: We hypothesized that officers who work the Day- or Mid-shift (Days: 10-12 hour shifts starting between 0500 and 0700 until between 1600 and 1800; Mids: 10-12 hour shifts starting between 1200 and 1400 until between 0000 and 0300) will have better ANS function and cardiovascular health than the Night-shift officers (10-12 hour shifts starting between 1800 and 2000 until 0500 and 0800). Specifically, Days and Mids will have higher resting HRV, in both time and spectral domains, lower RHR, higher VO_{2MAX} and higher percent-drop in HRR when compared to Night-shifters

Secondary hypothesis: Increased overtime hours, poor exercise habits, diminished sleep and elevated BMI and body-fat, will be predictive of lower HRV (time and spectral domain), higher RHR, lower maximal aerobic capacity (VO_{2MAX}), and diminished heart rate recovery (HRR).

Study Two: Physiological Implications of Psychosocial Factors and Occupational Stress in Police Officers

Aim one: To examine the relationship between psychosocial factors and physiological markers for cardiovascular health among patrol officers (excluded higher rank officers; e.g., sergeants, investigators, lieutenants, captains, chiefs).

Related hypothesis: Higher psychosocial scores (determined by the Police Occupational Stress Survey, *POSS*) for perceived work-stress (perceived inequality and exposure to critical incidents), negative coping strategies, and negative health outcomes (physical, emotional/behavioral and depressive indicators) will be predictive of higher levels of both traditional (blood pressure, total cholesterol, low-density lipoprotein (LDL) levels, triglycerides, serum cortisol concentrations) and non-traditional markers (C-reactive protein (CRP), Interleukin-6 (IL-6), Interleukin-1 Beta (IL-1β) and Tumor Necrosis Factor alpha (TNFα)) for cardiovascular health.

Secondary hypothesis: Higher administrative support, job satisfaction, and positive coping mechanism scores will be inversely related to lower traditional and non-traditional markers for cardiovascular health.

Study Three: Impacts of Shift-Work and Sleep on Physiological Markers of Cardiovascular Health in Police Officers

Aim one: To determine the influence of shift-work on both non-traditional and traditional markers of cardiovascular health among police officers.

Related hypothesis: Night-shift officers will exhibit greater expression of both non-traditional (C-reactive protein (CRP), Interleukin-6 (IL-6), Interleukin-1 Beta (IL-1β) and

Tumor Necrosis Factor-alpha (TNFα)) and traditional markers (body mass index (BMI), blood pressure, blood lipids, and cortisol) of cardiovascular health when compared to Day- or Mid-shift officers.

Aim two: To examine the relationship between shift-work and the Pittsburgh Sleep Quality Index (*PSQI*) indices.

Related hypothesis: Night-shift officers would have higher scores on the *PSQI* and its sub-scales (higher scales are indicative of poorer sleep) than Day- or Mid-shifters.

CHAPTER

2

LITERATURE REVIEW

CHAPTER TWO: Literature Review

2.1 The sympathetic nervous system

2.1.1. Acute stress response

The highly complex and integrated ANS is composed of two branches: The parasympathetic and sympathetic nervous systems. These branches balance automatic, involuntary functions within the body by utilizing nervous and hormonal interactions to control digestion, pupillary response, breathing, cardiovascular and blood pressure changes, sexual arousal and thermoregulation. Even though each branch has specific functions, they are often utilized simultaneously but with opposing magnitude given the physiological stimuli of the environment (external or internal). The normal stress response, whether due to physical, physiological or psychological stimuli, is mediated by both parasympathetic withdrawal and sympathetic stimulation, as a survival mechanism. Specifically, when a stressor is present, the hypothalamic pituitary adrenal (HPA) axis is activated, sending efferent signals via preganglionic motor neurons in the brain and spinal cord in the form of norepinephrine (Bard, 1928; Beattie, Brow, & Long, 1930; Sawchenko & Swanson, 1981; Swanson et al., 1981). Signals for cardiac influence are transmitted through paravertebral ganglia, forming the sympathetic trunk where postganglionic nerves innervate the cardiac and pulmonary plexuses, stimulating physiological cascades via adrenergic receptor activation.

Adrenergic receptors, a class of G-protein (guanine nucleotide binding protein) coupled receptors, are bound by norepinephrine (higher affinity) or epinephrine, and are separated into alpha (α), beta (β) and gamma (γ) sub-classes (Ahlquist, 1948). G-proteins have a variety of sub-units within each sub-class that all share a similar mechanism of activation, but may activate signaling cascades in different ways. In general, α_1 receptors are stimulatory in nature, and are present in all major sympathetic target organs. When norepinephrine or epinephrine bind to the α_1 receptor, conformational changes occur in the cytoplasm, causing an activation of the G_q protein, which signals a cellular cascade, resulting in the formation of cGMP (cyclic guanosine monophosphate; Lee, Kuo, & Greengard, 1972; Schultz, Hardman, Schultz, Baird, & Sutherland, 1973). These α_1 receptors cause vasoconstriction in smooth muscle vasculature, thereby raising blood pressure with sympathetic stimulation (Buckwalter, Naik, Valic, & Clifford, 2001; Pettinger, Keeton, Campbell, & Harper, 1976; Wray, Fadel, Smith, Raven, & Sander, 2004).

Alpha-2 (α_2) receptors, with sub-unit G_i proteins, present on the membranes of adrenergic axon terminals, are responsible for mediating the inhibition of norepinephrine release (Berthelsen & Pettinger, 1977; Langer, 1974). Alpha-2 stimulation also results in the increase blood platelet stimulation and clotting factors (von Känel & Dimsdale, 2000), vasoconstriction in the skin (Ekenvall, Lindblad, Norbeck, & Etzell, 1988) and pupillary dilation which increases light absorption onto the retina. This enhance the intake of visual stimuli which can improve an organism's survival in life-threatening situations (Koss, 1986). Alpha-2 receptors also constrict coronary arteries (Woodman & Vatner, 1987) though this effect may be blunted by β_2 receptor activation of coronary artery vasodilation (Sun et al., 2002).

Beta (β) adrenergic receptors are a class of G-proteins (sub-unit G_s) that bind norepinephrine. In general, β_1 adrenergic receptors, are primarily found in the heart and coronary blood vessels, kidneys, and the brain's cerebral cortex, hippocampus, diencephalon and caudate (Duncker, Stubenitsky, & Verdouw, 1998; Minneman, Hegstrand, & Molinoff, 1979). Norepinephrine raises cyclic adenosine monophosphate (cAMP) concentrations via adenylyl cyclase activation in the target cell. This cAMP binding can activate gene transcription for several cytokines (this will be discussed further in the following section). Adenylyl cyclase activation stimulates protein kinase A (PKA) phosphorylation to maintain Ca^{+2} in the sarcoplasmic reticulum. In the heart, β_1 adrenergic receptors increase heart rate and contractility while dilating coronary vasculature. In the kidneys, norepinephrine stimulates renin release which activates the renin-angiotensin aldosterone cascade to increase blood volume, and therefore, blood pressure (Luetscher & Johnson, 1954; Loeb, Atchley, Benedict, & Leland, 1933).

When activated, α_2 and β_2 receptors in the pancreas secrete glucagon into the bloodstream (Porte, 1967; Samols & Weir, 1979). Glucagon then binds to $G_{\alpha\beta\gamma}$ proteins in the liver, which activate adenylate cyclase through a conformational change of the GDP (guanosine diphosphate) molecule to a GTP (guanosine triphosphate) molecule via an α protein sub-unit (Berg, Tymoczko, & Gatto, 2002). Adenylate cyclase then manufactures cAMP which activates PKA to phosphorylate kinase (PPK) resulting in glycogen phosphorylation and the release of glucose into the blood stream. With concurrent pancreatic stimulation of insulin release and increased glucose secretion (Vosburgh & Richards, 1903), skeletal muscle increases its glucose uptake for rapid fuel utilization in fight-or-flight, survival situations. β_3 receptors, found primarily in adipose tissue, are responsible for stimulating lipolysis via PKA phosphorylation which is intended for long-term exertion in survival situations (Bamshad, Aoki, Adkison, Warren, & Bartness, 1998; Sztalryd et al., 2003).

Even though sympathetic influence affects numerous organs and tissues, the primary focus of this dissertation is to examine the role of the stress response with both acute and chronic stimulation among police officers. Acutely, as sympathetic drive increases, norepinephrine binds to β_1 adrenergic receptors (G_s proteins) which raises intracellular 3’ 5’-cyclic adenosine monophosphate (cAMP) concentrations via adenylyl cyclase activation (responsible for catalyzing ATP conversion to cAMP and pyrophosphate; Zimmermann, Zhou, & Taussig, 1998) within the target cell. Activated PKA phosphorylation maintains Ca^{+2} in the sarcoplasmic reticulum thereby increasing myocardial contractility, heart rate and dilation of coronary vasculature (Minneman, Hegstrand, & Molinoff, 1979). This enables adequate blood and oxygen perfusion to the necessary tissues during increased exertion, for example, when officers are pursuing suspects on foot or are in physical altercations with suspects.

Acutely, sympathetic activation is necessary in survival situations; however, chronic exposure to circulating catecholamines can down-regulate β adrenergic receptors (β receptor density; Aarons, Nies, Gerber, & Molinoff, 1983; Dimsdale, Mills, Patterson, Ziegler, & Dillon, 1994; Galant, Duriseti, Underwood, & Insel, 1978; Mills et al., 1997) and blunt an acute response when individuals, such as police officers, are placed in life-threatening situations. Beta-2 adrenergic receptors are found primarily in the lungs, coronary vasculature, cerebellum and most other sympathetic target organs including the pancreas, digestive and urinary tracts and female uterus (Carstairs, Nimmo, & Barnes, 1985; Minneman et al., 1979). Downstream signaling from β_2 receptors via PKA actively increases L-type calcium channel activity in the heart and brain (Bean, Nowycky, & Tsien, 1983; Gray & Johnston, 1987) and are also responsible for increased pro-coagulant activity via platelet activation (von Känel & Dimsdale, 2000; von Känel, Mills, Ziegler, & Dimsdale, 2002). Interestingly, numerous studies have shown that sympthoadrenal activity increases clotting factors in animals (Cannon & Gray, 1914; Vosburgh & Richards, 1903) and humans (Larsson, Wiman, Olsson, Angelin, & Hjemdahl, 1990; von Känel et al., 2002). Specifically, Biggs, MacFarlane and Philling (1947) found that increases in circulating epinephrine and exercise both stimulate fibrinolytic activity and increased platelet, neutrophil and lymphocyte activity. In addition, von Känel and Dimsdale (2000) found a dose-dependent relationship between infused epinephrine and factor VIII clotting activity, tissue-type plasminogen activator, platelets and von Willebrand factor antigen production. This increased clotting capability during an acute stress response would be advantageous for survival in the event of injury, but may be detrimental in individuals, including police officers, with poor cardiorespiratory fitness due to the potential for clots in coronary vasculature.

A large flood of catecholamines create a hyper-coagulative state in the vasculature and may make individuals more prone to thrombosis and SCD (von Känel & Dimsdale, 2003). This hyper-coagulative state may also have serious implications on atherosclerotic progression, which has been previously shown in police officer populations (Feuer & Rosenman, 1986; Joseph et al., 2009). Structural changes can occur within arterial endothelium, including accumulation of atherosclerotic plaques and scar tissue (Ross, 1999), leading to arterial stiffness and noncompliance, thereby contributing to orthostatic hypotension, coronary artery disease, hypertension and heart failure (Low et al., 1997; Nielsen, Hasenkam, Pilegaard, Aalkjaer, & Mortensen, 1992; Sutton-Tyrrell et al., 2005). Prolonged sympathetic tone, or continuous stimulation of the acute stress response, can also negatively impact immune system regulation through pro-inflammatory cytokine expression and diminished parasympathetic drive, which will be discussed below.

2.1.2. Pro-inflammatory cytokines

Cytokines are a class of protein involved in inter- and extra-cellular signaling processes with numerous auto-regulatory functions, but particularly in concurrence with immune system regulation. Elevated pro-inflammatory cytokine expression has been noted with greater frequency in recent pathophysiological research. Primarily, elevated cytokine expression occurs with higher incidence of diabetes and insulin sensitivity (Kristiansen & Mandrup-Poulsen, 2005), cardiomyopathy, atherosclerosis, previous MI, cancer (Bellone et al., 2006; Locksley, Killeen, & Lenardo, 2001), human immunodeficiency virus (HIV), rheumatoid arthritis, hepatitis C, multiple sclerosis, and mental disorders like schizophrenia, bipolar disorder, depression (Dowlati et al., 2010) and Alzheimer's (Swardfager et al., 2010). Increased expression of pro-inflammatory cytokines is evidenced with both acute (Berkenbosch, Van Oers, Del Rey, Tilders, & Besedovsky, 1987; Besedovsky, del Rey, Sorkin, Da Prada, Burri, & Honegger, 1983; Besedovsky, del Rey, Sorkin, Da Prada, & Keller, 1979; Besedovsky, del Rey, Sorkin, & Dinarello, 1986; Chrousos & Gold, 1992; del Rey, Besedovsky, Sorkin, Da Prada, & Bondiolotti, 1982; Dunn, 1988; Elenkov, Kovács, Kiss, Bertok, & Vizi, 1992; Kovács and Elenkov, 1995; Sapolsky, Rivier, Yamamoto, Plotsky, & Vale, 1987) and chronic sympathetic stimulation (Borysenko & Borysenko, 1982; Dowdell, Gienapp, Stuckman, Wardrop, & Whitacre, 1999; McCabe et al., 2000; Padgett, Marucha, & Sheridan, 1998), which has negative implications on immune system function both in the short- and long-term (Calabrese, Kling, & Gold, 1987; Glaser et al., 1992; Kiecolt-Glaser, Glaser, Gravenstein, Malarkey, & Sheridan, 1996; Segerstrom & Miller, 2004).

Specifically, Interleukin-1 beta (IL-1β), a pro-inflammatory cytokine produced in macrophages, B-cells, and monocytes, plays a fundamental role in response to infection. This response is especially true in lymphocyte and macrophage infiltration in response to inflammatory lesions in coronary arteries and the myocardium (Fenoglio, Ursell, Kellogg, Drusin, & Weiss, 1983; Schulz, Nava, & Moncada, 1992). In the heart, it has been suggested that IL-1β may be involved in the downregulation of Ca^{+2} within cardiomyocytes, which diminishes their contractile properties by stimulating nitric oxide synthase (De Belder, 1993; Francis, Holden, Holt, & Duff, 1998). In connection, serum levels of IL-1β have been significantly and positively associated with congestive heart failure ($p < 0.001$), angina ($p = 0.02$), serum Ca^{+2} levels ($p = 0.02$) and dyslipidemia ($p = 0.05$) (Di Iorio et al., 2003). Elevated levels of serum IL-1β have also been indicated in dilated cardiomyopathy suggesting its integral role in the pathogenesis of congestive heart failure and other cardiovascular morbidities (Francis et al., 1998). Increased IL-1β may blunt β_1 adrenergic receptors ability to increase heart rate and myocardial contractility in response to epinephrine and norepinephrine, thereby diminishing the cardiovascular response to increased exertion or acute stress.

Interleukin-6 (IL-6), like IL-1β, is produced by leukocytes (T-helper cells, macrophages, and lymphocytes) and is especially present in subcutaneous adipose tissue (Mohamed-Ali et al., 1997). IL-6 is involved in the final stages of B-cell differentiation into immunoglobulin-secreting cells (Hirano et al., 1986) and in acute phase reaction to hematopoiesis and inflammation (Heinrich, Castell, & Andus, 1990). IL-6 closely regulates the expression of C-reactive protein (CRP). CRP, which is produced in the liver and has more recently been utilized as a means to measure chronic and acute inflammation, is induced by oxidative stress. Presently CRP is a predictive marker for a variety of diseases and is predictive of higher future cardiovascular risk (Haverkate, Thompson, Pyke, & Gallimore, 1997; Koenig et al., 1999; Ridker, Cushman, Stampfer, Tracy, & Hennekens, 1997; Ridker, Hennekens, Buring, & Rifai, 2000a; Ridker, Rifai, Stampfer & Hennekens, 2000b). CRP has also been shown as a consistent predictor for the development of Type-2 diabetes mellitus in women when age, body mass index (BMI), smoking, physical activity, alcohol consumption, and family history of diabetes were all controlled for (Pradhan, Manson, Rifai, Buring, & Ridker, 2001). Therefore, both IL-6 and CRP expression may be used to understand individuals' risk profiles for future disease progression.

Tumor Necrosis Factor-alpha (TNFα), primarily produced by macrophages, natural killer (NK) cells, and mast cells, is another marker of systemic inflammation. TNFα is integral in cytotoxic environments and cellular necrosis and apoptosis (Carswell et al., 1975; Kolb & Granger, 1968; Ruddle & Waksman, 1968; Saren, Welgus, & Kovanen, 1996; Tournier et al., 2000). Although, cellular apoptosis and necrosis occurs as a natural physiological process, higher rates of cellular turnover may further stress the physiological mechanisms involved in cellular reproduction. Complex mitogen-activated protein kinase (MAPK) cascades are transiently increased with physiological stress and allow downstream extracellular signaling to amino acid transcription in cellular reproduction (Cavigelli, Dolfi, Claret, & Karin, 1995; Chang & Karin, 2001; Kyriakis et al., 1994; Widegren et al., 1998; Xing, Ginty, & Greenberg, 1996). MAPK cascades influence extracellular signal-regulated kinase (ERK) 1 and 2 and ERK 5, p38 MAPK (stress-activated protein kinase; SAPK2) and JNK (c-Jun N-terminal kinase; SAPK1). ERK 1 and 2 activation also occurs with cytokine influence (Ogata et al., 1997), G-protein-coupled receptor stimulation (Crespo, Xu, Simonds, & Gutkind, 1994) or hormonal influences (Hodge, Liao, Stofega, Guan, Carter-Su, & Schwartz, 1998). JNKs and p38 MAPKs are specific to stress-mediated activation (Johnson & Lapadat, 2002). Specifically, p38 MAPK has been shown to influence IL-1 and IL-6 presence and regulate TNFα expression (Beyaert et al., 1996*;* Lee et al., 1993; McLaughlin et al., 1996) suggesting a positive feedback mechanism between intracellular signaling with stress and resulting inflammatory processes. Overall this cellular process can burden the immune system, thereby blunting the normal response and transiently decreasing an organism's ability to handle acute stressors, infection and illness, which will be discussed below.

2.1.3. Inflammation and immune system function

During acute-phase initiation of the sympathetic drive, key pathways in immune system response are activated to enhance immune function. Numerous physiological mechanisms are interwoven between the SNS and the immune system, creating complex feedback loops and integrated responses (Elenkov, Wilder, Chrousos, & Vizi, 2000; Madden & Livnat, 1981). Cytokines IL-1, IL-6, and TNFα have been shown to directly impact the stimulation of the HPA-axis via corticotropin releasing hormone (CRH) (Berkenbosch et al., 1987; Besedovsky et al., 1983*;* Besedovsky et al., 1979; Besedovsky et al., 1986; Chrousos & Gold, 1992; del Rey et al., 1982*;* Dunn, 1988; Elenkov et al., 1992*;* Kovács and Elenkov, 1995; Sapolsky et al., 1987). CRH then stimulates glucocorticoids, like cortisol, and catecholamine secretion (Besedovsky et al., 1986; Chrousos, 1995; Cummings, Elde, Ells, & Lindall, 1983; Dunn & Berridge, 1990) primarily through α_1 adrenergic receptor activation (Chrousos, 1992; Sawchenko, Imaki, Potter, Kovacs, Imaki, & Vale, 1993). This response was first observed in rats exposed to stressors whose adrenal glands were enlarged while the thymus and lymph nodes were diminished (Selye, 1936). This tissue degradation may be partially due to the influence of TNFα and IL-1β in the extracellular matrix causing upregulation of certain extracellular, destructive enzymes, which lead to cellular apoptosis (Saren et al., 1996).

Sympathetic postganglionic nerves directly innervate vasculature smooth muscle and the parenchyma of lymph nodes, suggesting that controlled blood flow in these tissues may negatively impact lymphocyte production (Felten, Felten, Carlson, Olschowka, & Livnat, 1985; Vizi, Orso, Osipenko, Hasko, & Elenkov, 1995). This post-ganglionic innervation has been shown to negatively affect T-cell lymphocytes, monocytes, macrophages, granulocytes, and mast cell production (Blennerhassett and Bienenstock, 1998; Felten et al., 1985; Rabin, 1999). Concurrently, IL-1β influences a long cascade of responses, particularly in the splanchnic nerve, which leads to an increase in norepinephrine circulation, contributing to a positive feedback loop of expression between the sympathetic nervous system and lymphoid organ activation (Katafuchi, Hori, & Take, 1991; Zhang, Swiergiel, Palamarchouk, & Dunn, 1998).

Initially, immune system activation with an acute stress response is beneficial in survival situations in the event of injury and warding off potential infection. However, with chronic exposure to catecholamines and glucocorticoids, like cortisol, β adrenergic receptor stimulation of cAMP protein-binding can directly influence gene transcriptional mechanisms, which can negatively impact immune system function in the long-term (Ashwell, Lu, & Vacchio, 2000; Lee et al., 1988; Russo-Marie, 1992; Zanker, Walz, Wieder, & Strom, 1990; Zitnik, Whiting, & Elias, 1994). Specifically, this leads to decreased levels and functionality of both T- and B-lymphocytes, natural killer cells, neutrophils, and macrophages as well as suppressed levels of cytokines and chemokines responsible for adaptive immune system response in both animal (Borysenko & Borysenko, 1982; Dowdell et al., 1999; McCabe et al., 2000; Padgett et al., 1998) and human models (Calabrese et al., 1987; Glaser et al., 1992; Kiecolt-Glaser et al., 1996; Segerstrom & Miller, 2004). Continually suppressed immune system function in combination with higher cortisol and circulating pro-inflammatory cytokines, can lead to numerous disease states and poor health. As officers are exposed to a variety of stressors on a daily basis, their sympathetic tone may be chronically stimulated, thus contributing to the exposure of cortisol and pro-inflammatory cytokines. This positive feedback mechanism, in which immune system function is diminished while inflammation continues to be elevated, may be partially responsible for a higher incidence of disease and early death in police officers. Diseases that officers have higher incidence of will be discussed in depth in later sections.

2.2 The parasympathetic nervous system

2.2.1. Recovery post-acute stress

As officers face uncertain and critical incidents on the job, an instinctual acute-stress response occurs in order for them to respond appropriately to the situation. Normally, after a stressor has passed, parasympathetic tone increases via acetylcholine (ACh) release. Muscarinic

($M_{2/4}$) receptors in the heart activate via the G_i protein receptor, which decreases cAMP in the cell, due to inhibition of adenylate cyclase activity. This leads to an inhibition of voltage-gated Ca^{+2} channels thereby increasing cellular K^+ ions (Cuevas & Adams, 1997). This receptor cascade slows the heart rate and diminishes contractile force by slowing action potential conduction velocity via a lengthened refractory period and ventricular depolarization (Stengel, Gomeza, Wess, & Cohen, 2000). Even though response to an acute stressor is necessary in life-threatening situations, when the stress response is sustained, or there is insufficient recovery, there is a subsequent increase in allostatic load through sympathetic dominance and diminished vagal influence (McEwen & Stellar, 1993; Sterling, 2012; Thayer, Yamamoto, & Brosschot, 2010; Weber et al., 2010).

The allostatic model, different from homeostatic model, describes that human survival is based on a series of constantly fluctuating internal physiology within a constantly changing external environment (McEwen & Stellar, 1993; Sterling, 1988). The physiological integration of cellular cascades and their influence on organ systems is constantly in a state of homeorrhesis, or dynamic stability (Waddington, 1957). Physiological fluctuations to both physical and psychological stressors are accounted for in this model, suggesting that whether a stressor is environmental (external) or systemic (internal; physical or psychological) in nature, physiological mechanisms for the stress response still respond in similar ways (Sterling, 1988). Therefore, allostatic load results in chronic exposure to, and diminished recovery from, stressors accumulated over a lifetime. This theory has been established based on animal studies involving rodents' cumulative exposure to glucocorticoids (Sapolsky, Krey, & McEwen, 2002). Evidence of permanent degenerative changes in the hippocampus, which is responsible for glucocorticoid inhibition, have been noted. Hippocampal inhibition results in an impaired ability to halt glucocorticoid excretion post-stress which leads to continual degradation of the HPA axis and ultimately results in constant exposure of glucocorticoids (Sapolsky et al., 2002). Chronic exposure of glucocorticoids, as detailed above, can lead to increases in cytokine expression, systemic inflammation, and eventually immune system suppression, further contributing to allostatic load.

2.2.2. Heart rate variability (HRV)

Autonomic dysfunction, particularly higher sympathetic drive and diminished parasympathetic tone, can be measured via HRV analysis, which uses beat to beat time-interval analysis of heart rate changes to understand the adaptability of the ANS to external stimuli. Specifically, HRV analysis attempts to assess the allostasis of a system, which gives us a more complete picture of ANS health than evaluation of heart rate alone. HRV was first described in the human fetus as a determinant of distress prior to any change in heart rate (Hon & Lee, 1965). Primarily, HRV reflects cardiac output to central oxygen demands. Therefore, mediation by chemoreceptors in the carotid sinus are highly influential with postural changes. HRV also varies directly with respiratory sinus arrhythmia, mediated by vagal influence, with shorter beat-to-beat intervals upon inspiration, and longer intervals on exhalation (Eckberg, 1983; Hirsch & Bishop, 1981). Further, given the complexity of human diversity, HRV analysis is subject to intra-individual variability, genetic influences (Kupper et al., 2004; Singh et al., 1999) and various physiological/pharmacological conditions (Goldberger, Ahmed, Parker, & Kadish, 1994).

Interestingly, a higher HRV is considered to be indicative of a healthier and more adaptive ANS to environmental and systemic stimuli. Decreased HRV is indicative of ANS dysfunction. Specifically, low HRV has been shown to be a major predictor of poor cardiovascular health and higher risk for a negative cardiovascular event (Corr, Yamada, & Witkowski, 1986; Vrijkotte et al., 2000) independent of traditional risk factors like blood pressure, blood lipid levels, fasting blood glucose and BMI (Nakao, Nomura, Karita, Nishikitani, & Yano, 2004; Vrijkotte et al., 2000; Whitsel et al., 2001). Low HRV is a strong predictor of cardiovascular risk in healthy individuals (Kors, Swenne, & Greiser, 2007; Whitsel et al., 2001), has been related to increased mortality and morbidity in diseased individuals (Huikuri et al., 1999), and has also been associated with higher levels of circulating pro-inflammatory cytokines (Koenig et al., 1999; Lampert et al., 2008; Ridker et al., 2000a).

Weber et al. (2010) analyzed HRV and several endocrine and immune system markers post-acute stress response in 44 adult males. Participants were tested at baseline, immediately after and then again at 20 and 60 minutes post-stress test which consisted of two previously validated stress-inducing protocols. Researchers first put participants through the Manometer Test, a computer-based, time-bound, information processing assessment, and the second, a mental arithmetic test. Aside from HRV, researchers measured serum levels of cortisol, TNFα, and IL-6 as markers of immune response to stress. At 20 minutes post-stress test, individuals with high HRV showed cortisol levels decreased below baseline, whereas those with low HRV showed sustained levels of cortisol (Weber et al., 2010). Researchers also measured systolic and diastolic blood pressure and heart rate, finding that low vagal tone, as indicated by low HRV, was associated with impaired diastolic blood pressure. Participants with high HRV at 60 minutes post-test showed significantly decreased levels of circulating TNFα ($p<0.05$), whereas participants with low HRV showed no changes in TNFα serum levels. Therefore, those with lower HRV exhibit an increase in inflammatory cytokines circulation for longer periods following an acute exposure to stress which has been previously associated with an increased risk of cardiovascular events (Weber et al., 2010).

Similar work by Vrijkotte, Van Doornen, and De Geus (2000) examined the relationship between ambulatory blood pressure, heart rate and HRV in 109 male blue-collar workers. Cardiovascular reactivity and recovery to job stressors during and immediately after work were assessed. In this study, researchers found that work stress is significantly associated with increases in systolic blood pressure ($p<0.05$) and heart rate ($p<0.01$). The association between work-stress and ambulatory low HRV trended towards significance ($p=0.059$). Again, this suggests that *recovery* post-acute stress response may be crucial in determining health outcomes rather than *during* an acute stress response as evidenced in depressed resting HRV (Chandola et al., 2008; Vrijkotte et al., 2000). Therefore, it is important for officers to have adequate recovery time post-acute stress event to mitigate the expression of pro-inflammatory cytokines and to decrease blood pressure and heart rate. However, even with appropriate physical recovery post-stress, there may be more indicators that mental and emotional backlash have a higher effect on overall officer recovery, which will be discussed in a later section.

2.2.3. Heart rate variability analysis

Several methods for analyzing HRV have been established. Among them, time domain is the simplest and uses the most basic statistical methods to quantify the variation and standard deviation between successive RR intervals (regular to regular; or NN, normal to normal beats when corrected for artifact). This method is suspect to the duration of the measurement as more data points will have a greater standard deviation of RR/NN intervals (SDRR or SDNN). SDNN (measured in milliseconds, ms) is the standard deviation of normal RR and mean RR is the mean (ms) of RR intervals, which both reflects overall variability and homogeneity, respectively, over time. SDNN analysis is more applicable to long-term examination with upwards of 24-hours of recording (Tarvainen, 2014) and is reflective of both parasympathetic and sympathetic contribution (Shaffer & Ginsberg, 2017). In shorter-term, resting recordings (e.g., 5-10 minutes), SDNN is more parasympthetically modulated by resting sinus arrhythmia. Previous research has shown that in 24-heart rate (HR) recordings, participants with SDNN of less than 50ms are considered as unhealthy, 50-100ms is considered at risk, and greater than 100ms is healthy (Kleiger, Miller, Bigger, & Moss, 1987). No conclusive data has been found with shorter duration SDNN analysis.

RMSSD (root mean squared of successive differences; ms) is reflective of parasympathetic activity and is independent of mean HR (Fouad, Tarazi, Ferrario, Fighaly, & Alicandri, 1984; Hayano et al., 1991). This parameter is highly reproducible, is robust against *gradual* changes in heart rate over time, and is more appropriate for short term HRV analysis (Hilz & Dütsch, 2006; Tarvainen, 2014). Normative values for RMSSD have been indicated at

42±15 ms (Nunan, Sandercock, & Brodie, 2010). NN50 is the number of adjacent NN intervals differing by more than 50ms. pNN50 is the percentage of NN50 compared to the total amount of NN and is highly related to vagal tone (Shaffer, McCraty, & Zerr, 2014). HRV Triangular Index is a measure that is integral of the density of the NN interval histogram divided by its height. Triangular interpolation of the NN interval histogram (TINN) is the baseline width of the RR interval histogram (Shaffer & Ginsberg, 2017). The primary limitation of time domain analysis is its sensitivity to artifact (e.g., ectopic beats).

Frequency, or spectral, domain, first determined by Akselrod and associates (1981), utilizes variability as a power amplitude (Hz) in high, low, very-low and ultra-low frequency bands. The amplitude of each sin and cosine wave are determined by the biological input to the system's variational frequency. Fast-Fourier transformation (FFT), as opposed to Autoregressive (AR) analysis, evaluates time domain data as frequency data within power/amplitude (Hz) bands, then computes as absolute values of power (milliseconds squared, ms^2) or in normalized units (nu) (Malliani, Pagani, Lombardi, & Cerutti, 1991; Pagani et al., 1986). Primary values of interest for short-term frequency domain HRV measures primarily include measures of high frequency power (HF; between 0.15-0.4 Hz), low frequency power (LF; between 0.06-0.15 Hz), and LF/HF ratio (Shaffer & Ginsberg, 2017). HF is suggested to reflect respiratory driven vagal activity, whereas LF is said to reflect baroreceptor mediated blood pressure control, achieved by a balance between sympathetic and parasympathetic branches (Eckberg, 1983; Eckberg & Eckberg, 1982; Grossman & Taylor, 2005; Hayano et al., 1991; Kleiger, Stein, and Bigger, 2005; Laborde, Mosley, & Thayer, 2017; Pagani et al., 1986; Pomeranz et al., 1985). However, there is evidence that the spectral domain does not quantitatively evaluate sympathetic tone and may fail to differentiate pathophysiology, specifically with LF/HF ratio (Notarius, Butler, Ando, Pollard, & John, 1999; Seely & Macklem, 2004). LF/HF power ratio has been indicated in the past as a measure of sympathovagal balance, but this observation is based on the argument that LF reflects sympathetic dominance, which has been established as too linear and is not a valid (Billman, 2013). Previous research has indicated that normative data for average frequency domain measures of HRV include HF at 657±777 ms^2 or 40±10nu, LF at 519±291 ms^2 52±10nu, and LF/HF at 2.8±2.6 ms^2 (Nunan et al., 2010). However, given the breadth of standard deviation among HF and LF values, no definitive healthy or unhealthy range HRV values can be deduced. Overall, we can conclude from the current body of research, that the best means of determining vagal-influenced HRV indices in time and frequency domains that produce the most robust data are RMSSD, pNN50, and HF power measures (Camm et al., 1996; Kleiger et al., 2005; Laborde et al., 2017; Shaffer et al., 2014). HRV and good cardiovascular health will be discussed in further sections with relation to cardiorespiratory fitness and how HRV analysis can be utilized, in conjunction with other testing methods, to create a more complete health-risk profile.

2.3 Psychosocial factors

A psychosocial factor is defined as a psychological phenomenon that occurs due to a person's social environment and the pathophysiological changes associated with type-A/hostile personality, depression and anxiety, work characteristics and social support (Hemmingway & Marmot, 1999). For the purpose of this dissertation, psychosocial stress for officers is the physiological stress response to perceived demand (physical or emotional) of a situation and the resources (physical or emotional) at their disposal to respond to a given stressor (Anshel, 2000; Anshel, Robertson & Caputi, 1997; Biggam, Power, & MacDonald, 1997). Psychosocial stressors are either acute or chronic in nature. Acute psychosocial stressors are short in duration and as a result of a critical incident (e.g., physical altercation with a suspect, shooting someone in the line of duty). Chronic stressors result from repeated or accumulated acute incidents with inadequate positive coping mechanisms (Anshel, 2000; Evans & Coman, 1993). Often, the magnitude of psychosocial stress is impacted by a variety of factors. These include, but are not limited to, one's personal attributes such as personality and hardiness (Anshel, 2000; Tang & Hammontree, 1992), cognitive appraisal (Anshel, 2000, Anshel et al., 1997; Violanti & Aron, 1995), coping strategies (approach or avoidance (repression) focused; Anshel, 2000; Elliot, 1999), and social support

(Kirkcaldy, Cooper, & Ruffalo, 1995). Social support may be influenced by gender (Biggam et al., 1997).

Psychosocial stress has broader negative impacts on both job performance, including diminished quality of service to the community, poor work-family balance, higher rates of suicide, domestic abuse and substance abuse (Davey, Obst, & Sheehan, 2000; Loo, 1986). In a sample of 105 Police officers aged 50 and older, perceived work stress was significantly associated with anxiety, depression, somatization, symptoms of post-traumatic stress, symptoms of burn-out, alcohol abuse, aggressive behavior, and low-back pain (Burke, 1994; Gershon et al., 2002). Interestingly, there is also extensive evidence between higher occupational stress and diminished autonomic function. This has been evidenced in both decreased HRV (Chandola et al., 2008; Clays et al., 2011; Uusitalo et al., 2011; Vrijkotte et al., 2000) and increases in pro-inflammatory cytokine production (Raison, Capuron, & Miller, 2006) suggesting that psychosocial stress may lead to a broader incidence of systemic decrements in health. Specific aspects of psychosocial sources of stress will be further discussed below.

2.3.1. Occupational stress

Law enforcement is considered one of the most psychologically and physically stressful occupations (National Institute for Occupational Safety and Health, 2008). Officers often experience occupational stress both acutely and chronically. Acute stressors occur during critical incidents and life-threatening situations when officers are exposed to traumatic crime scenes with severely injured or dead victims, having personal relationships with victims, physical altercations, shootings, or being the subject of an internal affairs investigation (Gershon et al., 2002; Gershon et al., 2009). Further, stress reactivity in anticipatory incidents where officers are called in for back-up scenarios or when officers are in various physical postures, like in placing a hand on their holstered gun, have resulted in an immediate increase in heart rate (Anderson, Litzenberger, & Plicas, 2002). Researchers Anderson et al. (2002) also found that a single incidence of responding to an unpredictable situation while on duty resulted in higher average heart rate during all subsequent on-duty tasks, suggestive of improper physiological recovery after critical incidents within a shift. This data is consistent with other research (Anshel et al., 1997; Hickman, Fricas, Strom, & Pope, 2011). However, those officers who did not experience a critical incident or unpredictable situation on duty did not have an extended, elevated heart rate response during their shift suggesting lingering physiological effects of an acutely stressful incident (Anderson et al., 2002). Exposure to critical events can also create severe psychological and emotional issues and negative mental health outcomes such as clinical anxiety and depression, PTSD, burnout, somatization and substance abuse when not addressed (Gershon et al., 2002; Komarovskaya et al., 2011; Liberman et al., 2002; Solomon, 1988; Violanti & Aron, 1995).

There is evidence suggesting that higher amounts of perceived occupational stress may come from more chronic sources of stress, particularly in high-effort, low-reward mechanisms, within police department hierarchies. Higher perceived stress has been noted in relation to administrative conflicts, shift-work and shift-rotation schedules, issues with superiors and work-family balance (Burke, 1994; Evans & Coman, 1993; Franke, Ramey, & Shelley, 2002; Gershon et al., 2002; Gershon et al., 2009; Liberman et al., 2002; Violanti & Aron, 1995). Researchers Crank & Caldero (1991) assessed occupational stress in 182 officers among eight municipal police departments in which officers were asked to assess their primary sources of work stress. Officers averaged 11.4 years of service with a mean of 9.6 years at their current rank and position. Responses were coded into five primary sources of perceived stress including task environment, departmental organization, judiciary support, personal or family concerns, and city government support. Interestingly, threats to personal safety had the lowest ranked sources of stress (Crank & Caldero, 1991). The most common sources of stress were based in the departmental organization domain, specifically in officer relationships with superiors and in dealing with shift-rotation changes. These findings support previous data of organizational and supervisorial issues being consistent sources of officer stress (Brown & Campbell, 1990; Martelli, Waters, & Martelli, 1989) with shift-work ranking as second highest in comparison to departmental/administrative issues (Violanti & Aron, 1994).

2.3.2. Shift-work and sleep disturbance

Officers deal with multiple shift-time changes throughout each year that often occur every three to six months. The normal work day for officers consists of 10 to 12 hour shifts, which often carry into over-time if they are out on a call when their shift is over. These long hours in combination with forced overtime hours and shift-work have implications on circadian rhythm disturbance, sleep dysregulation and decreased quality and quantity of sleep (Charles et al., 2007; Neylan et al., 2002; Vgontzas et al., 2004; Vila & Kenney, 2002). Sleep disturbance can augment the physiological stress-response at work or higher perceived stress.

Extensive research has shown that disordered sleep and shift-work can lead to increased fatigue, impaired performance, cognition and concentration problems (Rajaratnam, et al., 2011; Vila, 2006), injury on the job (Violanti et al., 2012) and absenteeism (Fekedulegn et al., 2013; Rajaratnam, et al., 2011). Also, higher rates of disease, including obesity, metabolic syndrome, Type II diabetes (Karlsson, Knutsson, Lindahl, & Alfredsson, 2003; Niedhammer, Lert, & Marne, 1996; Sookoian et al., 2007; Van Amelsvoort, Schouten, & Kok, 1999; Violanti et al., 2009), gastrointestinal disorders (Caruso, Lusk, & Gillespie, 2004; Segawa et al., 1987), hypertension and cardiovascular disease/stroke (Kawachi et al., 1995; Knutsson, Jonsson, Akerstedt, & Orth-Gomer, 1986; Morikawa et al., 1999), and mental and emotional problems (Gordon, Cleary, Parker, & Czeisler, 1986; Scott, Monk, & Brink, 1997), are associated with sleep dysregulation. Inadequate sleep and circadian rhythm disruption influences sympathetic activation evidenced by increased levels of CRP, IL-6, TNFα, cortisol, and norepinephrine and epinephrine (Puttonen, Viitasalo, & Härmä, 2011; Redwine, Hauger, Gillin, & Irwin, 2000; Sookoian et al., 2007; Vgontzas et al., 2004; Yamasaki, Schwartz, Gerber, Warren, & Pickering, 1998). Increased sympathetic tone has also been demonstrated through HRV in shift-workers both on-duty (Furlan et al., 2000; Järvelin-Pasanen, Ropponen, Tarvainen, Karjalainen, & Louhevaara, 2013) and off-duty (Holmes et al., 2001; Su et al., 2008; Van Amelsvoort, Schouten, Maan, Swenne, & Kok, 2000). Due to the variable nature of police work, often-times involving multi-annual shift changes, it may be deduced that sympathovagal balance is chronically disturbed, thereby influencing incidence of decreased HRV and higher cardiovascular risk factors.

2.3.3. Post-traumatic stress disorder (PTSD)

There is a high prevalence of mental distress and PTSD among officers due to the nature of their job (Gershon et al., 2002; Hartley et al., 2011; Komarovskaya et al., 2011; Liberman et al., 2002; Violanti & Aron, 1995). PTSD is an exaggerated, over-expression of sympathetic activation above and beyond the normal response. PTSD is characterized by hypervigilance, exaggerated startle response and hyper-reactivity to trauma reminders in the absence of true threat (American Psychiatric Association, 2013). It has been suggested that increases in sympathetic stimulation and inadequate emotional regulation is responsible for this exaggerated stress response when no threat is present (Blechert, Michael, Grossman, Lajtman, & Wilhelm, 2007; Sack, Hopper, & Lamprecht, 2004; Sahar, Shalev, & Porges, 2001).

Carlier, Lamberts, and Gersons (1997) found that PTSD occurred in 7% of Dutch officers and PTSD symptoms were experienced by 34%. Similarly, Robinson, Sigman and Wilson (1997) found that 13% of officers suffered from PTSD in an Ohio police sample. It is estimated that over the course of their career, critical incidents that officers will face include exposure to 25 dead bodies, 14 decaying bodies, 10 sexually assaulted children, badly/mortally injured colleagues twice, and being injured or shot at themselves more than once (Weiss et al., 2010). Therefore, in conjunction with daily stressors that officers face in the line of duty, high-risk or highly emotional scenarios over a career may have cumulative effects on officer's mental and emotional health as evidenced in higher rates of anxiety, depression and PTSD than the general population (Gershon, et al., 2002; Hartley et al., 2012; Komarovskaya et al., 2011; Liberman et al., 2002; Violanti & Aron, 1995).

Previous research in officers has shown that PTSD is linked to increased circulating levels of pro-inflammatory cytokines like IL-6 and CRP (McCanlies et al., 2011), which has been previously discussed as a potential indicator of immune system and autonomic dysfunction (Koenig et al., 1999; Lampert et al., 2008). There is clear evidence in previous literature that PTSD is highly associated with diminished HRV (Cohen et al., 2000; Cohen et al., 1998; Hauschildt, Peters, Moritz, & Jelinek, 2011; Keary, Hughes, & Palmieri, 2009; Shah et al., 2013). Even though higher levels of documented stress has been noted in officers, there may potentially be more psychological health issues due to the maladaptive coping mechanisms officers utilize to cope with PTSD (Gershon et al., 2002). We can, therefore, determine that police officers who suffer from some level of PTSD, may have higher sympathetic activation when no threat is present, thereby contributing to higher levels of inflammation and increased allostatic load.

2.3.4. Poor coping mechanisms

Occupational stress in officers is associated with improper recovery and maladaptive coping mechanisms (Dietrich & Smith, 1986; Gerson et al., 2009; Gershon et al., 2002; Swatt, Gibson, & Piquero, 2007). Alcohol consumption, smoking, and lack of physical activity, considered maladaptive coping mechanisms, can influence the risk of developing CAD (Hemmingway & Marmot, 1999). Further, officers have equal or higher self-reported tobacco (Franke et al., 2002) and alcohol abuse compared to the general population (Arrigo & Garsky, 1997; Davey et al., 2000; Dietrich & Smith, 1986; Gershon et al., 2002). Compulsive drinking was associated with negative mood and chronic thought suppression, indicating that alcohol may diminish normal emotional regulation (Denson, Grisham, & Moulds, 2011; Ingialdsson et al., 2003).

Numerous studies have indicated that alcohol inhibits regulation of the HPA axis shown in higher circulating cortisol and inhibitory feedback patterns involving the amygdala and pre-frontal cortex (Adinoff, Iranmanesh, Veldhuis, & Fisher, 1998; Thayer & Brosschot, 2005; Wand & Dobs, 1991). This imbalance is often due to a disturbance in systemic regulation. In a study by

Ingjaldsson, Laberg, and Thayer (2003), individuals suffering from alcoholism had lower HRV than healthy controls. Other studies have demonstrated that both acute and chronic alcohol consumption results in decreases in HRV (Koskinen, Virolainen, & Kupari, 1994; Murata et al., 1994; Thayer, Hall, Sollers, & Fischer, 2006).

Collectively, the previous research demonstrates that given the multiple avenues of occupational stress that officers face, it is prudent to examine positive coping mechanisms necessary for physical, psychological and physiological recovery. Maladaptive stress coping mechanisms may be a critical element in determining officer health over the course of their career and after. Without adequate recovery, acute and chronic sources of occupational stress may lead to increased allostatic load. This effects not only each officer's health and quality of life, but the health of their relationships, their departments, and subsequently, their communities. We will examine how officer lifestyle choices and physical fitness may further impact their ability to handle occupational stress and their ability to deal with the psychosocial implications of police work.

2.4 Lifestyle factors and cardiovascular health

2.4.1. Obesity and poor cardiovascular fitness

Obesity, and in particular visceral adiposity, has in recent decades become a major health concern in the general population. In the most up to date statistics, more than one-third of U.S. adults are considered obese (Ogden, Carroll, Kit, & Flegal, 2013). BMI is still the greatest predictor for disease risk over time (Brown et al., 2000; Launer, Harris, Rumpel, & Madans, 1994; Rissanen et al., 1990; Visscher et al., 2004) even though rates of disease have dropped in overweight and obese groups in recent years (Gregg et al., 2005). Even though critical incidents, high-stress scenarios and highly physical incidents occur in police work, the majority of officer time is sedentary. As demonstrated in the general population, a higher incidence of obesity is directly associated with poor physical fitness and sedentary lifestyles (Healy, Matthews, Dunstan, Winkler, & Owen, 2011; Katzmarzyk, Church, Craig, & Bouchard, 2009). Unfortunately, police officers, on average, have equal or higher BMI compared to the normal population (Alasagheirin & Grueskin, 2011; Franke et al., 2002; Smolander, Louhevaaral, & Oja, 1984) and tend to gain weight and decrease their physical activity with age (Boyce, Jones, Lloyd, & Boone, 2008; Sörensen, Smolander, Louhevaara, Korhonen, & Oja, 2000; Stamford, Weltman, Moffatt, & Fulco, 1977).

Compared to the general population, officers have higher self-reported levels of hypertension and hypercholesterolemia (Franke et al., 2002) and incidence of metabolic syndrome (Hartley et al., 2012; Sassen et al., 2009; Thayyil, Jayakrishnan, Raja, & Cherumanalil, 2012) with higher rates seen in officers who take on more overtime hours and overnight shift-work (Violanti et al., 2009). Extensive research has linked metabolic syndrome, and its comorbidities, to decreased HRV (Koskinen et al., 1994.; Liao et al., 1998; Min, Min, Paek, & Cho, 2008; Stein et al., 2007). Concurrently, obesity and insulin resistance has been associated with elevated cytokine (TNFα, IL-6 and CRP) expression as well (Festa, D'agostino, Howard, Mykkänen, Tracy, & Haffner, 2000; Visser, Bouter, McQuillan, Wener, & Harris, 1999; Yudkin, Stehouwer, Emeis, & Coppack, 1999). This suggests that officers who have risk factors for metabolic syndrome, including obesity, hypertension, dyslipidemia and impaired glucose metabolism are at a higher risk for autonomic dysfunction and chronic inflammation, which can lead to higher future disease risk.

According to Franke et al. (2002), two of the best predictors for CVD in law enforcement were time spent in their profession and physical inactivity. In addition to the burden on the vasculature, obesity can also negatively influence sympathetic function. Dietrich and colleagues (2008) analyzed HRV and its relation to BMI and physical activity in a middle-aged Swiss cohort over a 12-year span. Researchers in this study found that sedentary, normal-weight participants had a 14% higher HRV (again this is considered favorable from an autonomic regulation standpoint) compared to sedentary, obese participants. When specifically looking at physical activity, both obese and normal weight individuals who exercised regularly had 19% greater HRV than their sedentary counterparts (Dietrich et al., 2008). Further, Kaikkonen et al., (2014) investigated HRV, physical activity, and aerobic fitness in obese adults and found that 24-hour ambulatory HRV was higher in all spectral domain measurements of HRV for fitter, obese individuals compared to the unfit comparison group (Kaikkonen et al., 2014). This indicates that even though obesity is associated with numerous comorbidities and low HRV, regular cardiovascular exercise can still positively benefit autonomic balance.

2.4.2. Traditional cardiovascular markers and heart rate variability

Huikuri et al. (1999) analyzed HRV and the progression of coronary atherosclerosis in 265 patients with prior coronary artery bypass and low HDL cholesterol (good cholesterol) levels. Twelve hour ambulatory readings of HRV were assessed at baseline and 32 months. This study found that low HRV was a major predictor of coronary artery disease (CAD) progression when lifestyle, cardiac disease history and medication were all adjusted for. HRV also provided a better picture of coronary atherosclerosis beyond traditional markers of measurement. It was deduced that the association between low HRV and the progression of CAD was not related to the severity of ischemic heart disease nor other common factors associated with atherosclerosis (Huikuri et al., 1999). Therefore, it was concluded that HRV may be independently related to atherosclerotic disease progression and used as a prognostic tool for CAD.

Further, atherosclerotic progression and decreased HRV has been associated with chronic low grade inflammation, as evidenced by higher circulating levels of CRP and IL-6 (Koenig et al., 1999; Lampert et al., 2008; Ridker et al., 2000a). As previously discussed, increased pro-inflammatory cytokines, specifically CRP, have been shown to relate to increased incidence of serious or fatal cardiovascular events and stroke in older women (Ridker et al., 2000a). It is also a predictor of future CAD and myocardial infarction (MI) in otherwise healthy middle-aged men (Haverkate et al., 1997; Koenig et al., 1999; Ridker et al., 1997). Additionally, previous work (Ridker et al., 2000b) has found that IL-6 is a strong predictor of future MI in otherwise healthy men after adjustment for other cardiovascular risk factors. Also, research indicates a strong correlation between IL-6 and CRP levels ($r=0.43$, $p<0.001$; Ridker et al., 2000b). It was suggested that using both traditional blood markers (lipid markers) and pro-inflammatory markers, like CRP and IL-6, can provide better prognostic indicators of future atherosclerotic progression and CAD risk when utilized together (Ridker, Rifai, Rose, Buring, & Cook, 2002). Therefore, analysis of HRV, pro-inflammatory cytokines and lipid markers may provide a more complete picture of cardiovascular and autonomic health than any single measure on its own.

2.4.3. Heart rate recovery (HRR)

Heart rate recovery has been used more commonly as an easy method to determine cardiovascular fitness and cardiovagal function through parasympathetic-reactivation post-exercise. Specifically, the period of recovery immediately post-exercise has become a widely used prognostic tool to determine ANS and cardiovascular health (Lahiri, 2008). In healthy individuals, within the first minute post-exercise, the SNS quickly withdrawals due to the body's decreased work rate and diminished physiological demand for oxygen. Parasympathetic reactivation occurs, slowing the heart rate and decreasing blood pressure.

Jouven et al. (2005) measured resting heart rate, heart rate rise from resting to peak exercise, and the decrease from peak exercise to one minute post-exercise within 5,713 asymptomatic working men, between the ages of 42 and 53 years. Researchers followed up with these participants over the next 23 years comparing incidents of SCD due to MI. When participants' heart rate recovery (HRR) was greater than 40bpm in reduction within one minute post-exercise, participants had the highest prognostic value for survival. Participants whose HRR was less than 25bpm, had the greatest risk at 2.2 times when compared to the highest percentile HRR group (Jouven et al., 2005). This suggests that those who remained more cardiovascularly fit had lower incidence of SCD over time than those who neglected their cardiovascular fitness.

2.4.4. Cardiorespiratory endurance training

Several studies have shown that HRV and CAD morbidities, like hypertension and elevated blood lipid profiles, can be improved via regular exercise in both diseased and healthy individuals (Hautala, Kiviniemi, & Tulppo, 2009; Mourot, Bouhaddi, Perrey, Rouillon, & Regnard, 2004; Routledge, Campbell, McFetridge-Durdle, & Bacon, 2010). Chronic endurance training results in morphological changes in myocardial tissue which leads to an increased number and size of cardiac myocytes shown in left-ventricular (LV) hypertrophy (Ehsani, Hagberg, & Hickson, 1978) and LV compliance (Levine, Lane, Buckey, Friedman, & Blomqvist, 1991). Subsequently, a stronger heart leads to increases in stroke volume and contractility, both at rest and during exercise. So less work, and therefore myocardial oxygen demand, is needed to maintain cardiac output (Bevegård, Holmgren & Jonsson, 1963; Ekblom, Åstrand, Saltin, Stenberg, & Wallström, 1968; Gledhill, Cox, & Jamnik, 1994). Aerobic exercise also improves ANS health by increasing vagal tone, and thereby to further contributes to lower resting heart rate (Smith, Hudson, Graitzer, & Raven, 1989) and increased HRV, leading to a substantial decrease in physiological stress on the body overall (De Meersman, 1993; Hauttala et al., 2009; Lee, Wood, & Welsch, 2002; Mourot et al., 2004).

Even short-term endurance training has been shown to positively impact sympathetic function as evidenced by higher HRV. Lee et al. (2002) examined the effect of a two-week (eight session) endurance training program on HRV (during passive tilt and five-minute paced breathing) and aerobic fitness in untrained, college males. The exercise group cycled at 80-85% heart rate reserve for 40 minutes, four times per week, while the control group remained sedentary. At study conclusion, the experimental group increased their maximal aerobic capacity (VO_{2MAX}) by eight percent and had significantly increased HRV ($p<0.05$) during passive tilt and paced breathing at rest (Lee et al., 2002). This acute effect is magnified with extended training. In a study by Mourot et al. (2004), acute endurance cycle training (six weeks) in young, sedentary males was compared with chronically trained cyclists (three-year amateur team athletes). Within the control group, from pre- to post-training, higher resting HRV was evident. Between groups, chronically trained individuals had significantly ($p<0.05$) higher resting HRV than the acutely trained (Mourot et al., 2004). In another study (De Meersman, 1993), 72 male runners were compared with 72 age- and weight-matched, sedentary control participants in measures of HRV at rest and exercising oxygen consumption. Not surprisingly, not only did the active group have higher VO_{2MAX} levels, but they demonstrated higher HRV as well (De Meersman, 1993).

Interestingly, exercise training has been shown to lead to improvements in reactivity to psychosocial stress as well. Rimmele and colleagues (2009) analyzed results from a standardized psychological stress test protocol (Trier Social Stress Test) performed by professional, amateur and untrained distance runners. Salivary cortisol and heart rate measures were taken at baseline and at varying time intervals post-stress test. Salivary cortisol post-test was significantly lower in professional runners ($p<0.05$) when compared to both amateur runners and untrained men. This adaptive response to stress due to endurance exercise has been duplicated in numerous studies (Hamer & Steptoe, 2007; Klaperski, von Dawans, Heinrichs, & Fuchs, 2013; Rimmele et al., 2007; Spalding, Lyon, Steel, & Hatfield, 2004; Tonello et al., 2007; Traustadóttir, Bosch, & Matt, 2005). Therefore, given the evidence of blunted physiological and psychological stress with cardiovascular training, officers could positively benefit from aerobic exercise as a means to cope with job-induced psychosocial stress. Overall, this could diminish officers' allostatic load and potentially produce better, future physical health outcomes both physically and psychologically.

CHAPTER

3

METHODS

CHAPTER THREE: Methods

Various methods of analysis were utilized in this study to measure both cardiovascular health and autonomic function, as well as the psychological stress and psychosocial impact of police work. Each method has been used and previously validated and will be discussed below.

3.1 Participant recruitment and scheduling

Police officers were recruited from local area police departments in the Minneapolis-St. Paul metropolitan area. Preliminary communication with the officers was initiated by sending each department chief a letter of recruitment (Study One: Appendix A, Studies Two and Three: Appendix E) detailing information about testing procedures, participant inclusion criteria and the expression of interest to come speak to their officers in person. After which, with permission, testing procedures and study details were verbally presented at each department's pre-shift roll-call (mandatory proceedings for all on-duty officers) for all shifts to inform individual officers of study proceedings.

Officers were then sent a recruitment email (Study One: Appendix B, Studies Two and Three: Appendix F) to garner interest in participation or could indicate in person whether they wanted to schedule an appointment. Pretesting instructions (Study One: Appendix C, Study Two and Three: Appendix F) were given to each participant prior to their data collection appointment. Informed consent was given prior to any data collection (Study One: Appendix D, Study Two and Three: Appendix G).

3.2 Study one: Lab testing

3.2.1. Occupational and lifestyle variables

After obtaining consent, officers were briefed on testing procedures. Officers were then given a short survey about various occupational and lifestyle tendencies (Appendix: E). The participants height and weight were then assessed prior to the first test.

3.2.2. .Heart rate variability analysis

Resting HRV was analyzed using a Polar heart rate monitor and a Polar s810 wrist computer watch (Polar, Kempele, Finland) which has been verified as a valid means of measuring HRV in research settings (Vanderlei, Silva, Pastre, Azevedo, & Godoy, 2008). The participant was fit with a heart rate monitor chest strap and was instructed to lie comfortably on his/her back on the testing table. During the 30-minute testing time frame, participants were asked to rest comfortably but not sleep. They were also informed that the researcher would check-in half way through the procedure time to ensure they remained awake.

Both time domain and frequency (spectral) domain analyses of HRV were utilized in our first study design using Kubios HRV Analysis software (Kubios HRV 2.2, Kuopio, Finland). Within the 30-minute time frame of rest, a ten-minute sample was extracted from a central point of the total data collection time. This enabled the participant to completely relax and afforded a more consistent mean resting heart rate (Berkoff, Cairns, Sanchez, & Moorman, 2007). HRV data was then uploaded into the Kubios Software and pre-processed with moderate artifact correction, which removes technological (e.g., missed beats, poor connection between HR monitor strap and Polar watch) or physiological error (e.g., ectopic beats) without influencing normal RR interval data (Jarrin, McGrath, Giovanniello, Poirier, & Lambert, 2012).

3.2.3. Hydrostatic weighing

Participants were then asked to change into a swimsuit or compression clothing for under-water (hydrostatic) weight analysis. Upon entering the underwater weigh tank (temperature ~ 98-102°F) and sitting on the weighing platform, participants were informed of underwater weighing procedures. Participants were instructed to fully submerge and maximally exhale, at which point their underwater weight was collected. Participants were then audibly signaled to return to the surface. After a total of five to ten trials, the two lowest body-fat composition values were averaged.

3.2.4. Maximal aerobic capacity (VO_{2MAX}) test

VO_{2MAX} was measured by gas exchange analysis using the Medgraphics Ultima system (MGC Diagnostics, St. Paul, MN). Prior to testing, a three-liter syringe was used to calibrate gas by using two different gas mixtures, 21% O_2/79% N_2 and 5% CO_2/12% O_2/83% N_2 (MGC Diagnostics, St. Paul, MN). Participants were asked to change into exercise attire and footwear to perform the VO_{2MAX} test and were fitted with a facemask and pneumatachograph to ensure gas collection throughout the test. Respiratory volume, rate and gases were monitored as well as heart rate via a Polar s810 wrist computer (Polar, Kempele, Finland). The standard Bruce VO_{2MAX} Protocol (Appendix F; Bruce, Kusumi, & Hosmer, 1973) was performed using a Woodway treadmill (Woodway, Waukesha, WI, USA). All participants were asked to give maximal effort and the test was voluntarily terminated when participants were fully exhausted. As HRR after maximal exercise has been previously utilized to measure cardiovascular fitness and parasympathetic health (Lahiri, 2008; Jouven et al., 2005), a two-minute time interval of heart rate was recorded immediately post-VO_{2MAX} test. Kubios software (Kubios HRV 2.2, Kuopio, Finland) was used to analyze percent of heart rate decline over the corresponding two minutes post-test.

3.3 Study two and three: Field testing

3.3.1. Blood pressure

Upon arrival to each police department, participants were fully consented and informed of the testing procedures. Participants then sat in a comfortable position for ten minutes prior to the blood pressure assessment. An appropriately sized blood pressure cuff was placed on the right arm of the participant, just superior to the antecubital fossa. Using a stethoscope on the participant’s brachial artery and a sphygmomanometer, the researcher rapidly inflated the blood pressure cuff to 220 mmHg. Pressure was slowly released until both systolic and diastolic Korotkoff sounds were assessed.

3.3.2. Blood sample collection and storage

Fasting blood samples were collected in 3mL lithium heparin tubes for blood lipid concentrations and in 5mL anticoagulant, serum-separator tubes for cortisol, IL-1β, IL-6, TNFα, and CRP analysis. Within an hour of the blood draw, blood collection tubes were centrifuged at 3000 RPM (1500G) at 4°C for 15 minutes to separate blood cells from plasma and serum, respectively. Separate aliquots of plasma and serum were then stored at -80°C until future analysis.

3.3.3. Blood biomarker analysis

A full-lipid panel was assessed for total cholesterol, high-density lipoprotein (HDL) cholesterol, low-density lipoprotein (LDL) cholesterol, and triglycerides (Dimension Vista 1500 Intelligent Lab System, Siemens Medical Solutions USA, Inc., Tarrytown, NY). Serum concentrations for cortisol were analyzed via direct chemiluminescent assay (ADVIA Centaur XP Immunoassay System, Siemens Medical Solutions USA, Inc., Tarrytown, NY) using standardized procedures.

Serum IL-1β, IL-6, and TNFα concentrations were measured using a high-sensitivity multiplex magnetic, color-coded beads pre-coated with anti-human antibody for each respective cytokine (R&D Systems, Minneapolis, MN). After incubation, and washing, biotinylated anti-human detection antibody was added followed by phycoerythrin-conjugated streptavidin via Luminex instrument analysis (Bio-Plex 200, Bio-Rad Laboratories, Inc., Hercules, CA). Samples were duplicated and fit to standard curves generated on each 96-well microtiter plate.

Serum CRP concentrations were measured using a high-sensitivity quantitative sandwich enzyme linked immunosorbent assay (ELISA) in 96-well plates (R&D Systems, Minneapolis, MN). Each well was pre-coated with a CRP detection antibody. Standards, samples and controls were then pipetted into the wells. After incubation, the plate was washed and an enzyme-linked conjugate was added. After incubation, the plate was washed and a substrate solution was added. The color development was then stopped and the intensity of the absorbance was measured on a microtiter plate reader (Epoch Microplate Spectrophotometer, Biotek Instruments, Winooski, VT). The values were interpolated from a log-log fitted standard curve. Each sample was analyzed using duplicate measures.

3.3.4. Sleep evaluation: Pittsburgh Sleep Quality Index (PSQI)

Officers were asked to self-report their sleep quality regarding the previous one month time period using the *PSQI* (Appendix H). The *PSQI* examines sleep quality, measured on a 5-point Likert scale, across seven areas of sleep. These sub-scales assess: (1) subjective sleep quality, (2) sleep latency, (3) sleep duration, (4) habitual sleep efficiency, (5) sleep disturbances, (6) use of sleep medication and (7) daytime dysfunction during the previous month. In addition to scores on these seven sub-scales, a global score was totaled. Studies indicate good internal consistency, reliability and validity for this scale (Buysse et al., 1989).

3.3.5. Occupational stress evaluation: Police Occupational Stress Survey (POSS)

This 126-item survey (Appendix I) was specifically designed for analyzing common stressors that police officers face in their occupation and corresponding adverse health outcomes. It has been previously validated (Gerson et al., 2002). Officers were asked to rate each item on a Likert-type scale (e.g., “strongly agree” to “strongly disagree). The *POSS* included questions regarding both demographic information and psychosocial factors on four major constructs: Perceived sources of occupational stress, personal outlook, coping mechanisms, and health outcomes. Sources of occupational stress were grouped into the following four categories: (1) Administrative support (e.g., the administration supports officers who are in trouble, I can trust my work partner), (2) perceived inequality (e.g., the department tends to be more lenient in enforcing rules and regulations for female officers; I feel that I am less likely to get chosen for a promotion because of “who I am”), (3) critical incidents (e.g., shooting someone in the line of duty; making a violent arrest; personally knowing a victim), and (4) job satisfaction (e.g., I have accomplished many worthwhile things in my career). Personality factors, categorized as personal outlook, included one category of items relating to officer personal beliefs and social interactions affected by their occupation (e.g., my beliefs about my personal safety, spirituality, outlook, etc. have been changed by my perspectives at work; I feel like I treat the public as if they were impersonal objects). Coping mechanisms included two sub-categories: (1) Positive coping mechanisms (e.g., pray for guidance and strength; exercise regularly to reduce tension); and (2) negative coping mechanisms including both avoidance strategies (e.g., try to act as if nothing is bothering you; stay away from everyone, you want to be alone) and negative behaviors (e.g., how often do you let your feelings out by smashing, breaking, or punching things; how often do you drink more than you planned; how often do you use tobacco/smoke more to help you relax). Finally, health outcomes were grouped into: (1) Physical health outcomes (e.g., do you suffer from: migraines, high-blood pressure, low back pain), (2) emotional/behavioral symptoms (e.g., how often: do you have feelings of being trapped or caught, do you feel like you have a lump in your throat, do you crying easily) (3) depressive tendencies (e.g., I want to withdraw from the constant demands on my time and energy from work; I have difficulty concentrating on my job; I feel negative, futile, or depressed about work).

The *POSS* was scored and coded according to prior methods (Gerson et al., 2002). Global scores in each of sub-scale within the four primary categories were scored individually and averaged for the total sample of officers. In addition, scores for specific items within certain sub-scales were also scored individually and analyzed for prevalence within our sample of officers.

CHAPTER

4

STUDY ONE

CHAPTER FOUR: Study One: Lifestyle and Occupational Variables and Cardiovascular Health in Police Officers

4.1 Introduction

Previous research indicates that officers on duty are more likely to die of sudden cardiac death (SCD) than any other private sector occupation (Calvert, Merling, & Burnett, 1999; Tiesman, Swedler, Konda, & Pollack, 2013). Rates of SCD often coincide with high-effort/low-control scenarios including physical altercations, suspect pursuits and medical-rescue operations (Varvarigou et al., 2014). Compared with the general population, police officers have higher rates of risk factors for SCD such as coronary heart disease and stroke (Pyörälä, Miettinen, Halonen, Laakso, & Pyörälä, 2000b), endothelial dysfunction (Joseph et al., 2010; Violanti et al., 2006) atherosclerotic progression (Feuer & Rosenman, 1986; Joseph et al., 2009), hypertension (Pyörälä, Miettinen, Laakso, & Pyörälä, 2000a), various cancers (Forastiere et al., 1994; Gu, Charles, Burchfiel, Andrew, & Violanti, 2011) and higher levels of pro-inflammatory cytokines (Ramey, Downing, Franke, Perkhounkova, & Alasagheirin, 2011).

Occupational variables specific to police officers, including shift-work, long/over-time hours and poor work-family balance, in addition to playing witness to violent crime scenes, suicide, death, and exposure to life threatening situations, can lead to negative physical and mental health outcomes (Gershon et al., 2002; Komarovskaya et al., 2011; Liberman et al., 2002; Solomon, 1988; Violanti & Aron, 1995). These occupational hazards in combination with personal lifestyle choices such as physical inactivity, poor diet, poor sleep and maladaptive coping mechanisms may be directly related to increased cardiovascular morbidities and higher mortality rate than the general population (Feuer & Rosenman, 1986; Franke, Collins, & Hinz, 1998; Vena et al., 1986; Violanti et al., 2013; Violanti et al., 1998).

In life-threatening, or critical/high-risk incidents, the normal stress reaction is initiated by sympathetic nervous system stimulation, which induces a cascade of neural and hormonal responses (Bard, 1928; Beattie et al., 1930; Sawchenko & Swanson, 1981; Swanson et al., 1981).

Though response to an acute stressor is necessary in survival situations, if the stress response is prolonged, or there is inadequate recovery from a stressor, increased allostatic load occurs via sympathetic dominance and diminished vagal tone. Numerous studies suggest that increased sympathetic dominance creates higher physiological stress, and over time, a subsequent decrease in heart rate variability (HRV; McEwen & Stellar, 1993; Sterling, 2012; Thayer et al., 2010; Weber et al., 2010). Decreased HRV is indicative of poor autonomic nervous system (ANS) function, poor cardiovascular health and a risk factor for future cardiovascular events (Corr et al., 1986; Huikuri et al., 1999; Vrijkotte et al., 2000) independent of traditional risk factors like blood pressure, cholesterol, fasting blood glucose and body mass index (BMI) (Nakao et al., 2004; Vrijkotte et al., 2000; Whitsel et al., 2001). Further, decreased HRV has been previously linked with increased mortality and morbidity in diseased individuals (Huikuri et al., 1999) and is a strong predictor of cardiovascular risk in healthy individuals (Kors et al., 2007; Whitsel et al., 2001).

The primary aim of this study was to examine the association between lifestyle and occupational variables and their effects on ANS function and cardiovascular health among police officers. To our knowledge, no previous study has evaluated the effects of BMI, body composition, sleep and exercise habits, shift-work and hours of overtime on HRV indices, resting heart rate (RHR), VO_{2MAX}, and heart rate recovery (HRR) in police officers. It is important to understand how these variables may influence ANS and cardiovascular health so that interventions can be implemented to improve officer health.

We hypothesized that officers who work the Day- or Mid-shift (Days: 10-12 hour shifts starting between 0500 and 0700 until between 1600 and 1800; Mids: 10-12 hour shifts starting between 1200 and 1400 until between 0000 and 0300) will have better ANS function and cardiovascular health than the Night-shift officers (10-12 hour shifts starting between 1800 and 2000 until 0500 and 0800). Specifically, Days and Mids would have higher resting HRV, in both time and spectral domains, lower RHR, higher VO_{2MAX} and higher percent-drop in HRR when compared to Night-shifters. Further, we also hypothesized that increased overtime hours, poor exercise habits, diminished sleep and elevated BMI and body-fat, would be predictive of lower HRV (time and spectral domain), higher RHR, lower maximal aerobic capacity (VO_{2MAX}), and diminished heart rate recovery (HRR).

4.2 Methods

4.2.1. Recruitment

Officers were recruited from local Minneapolis-St. Paul, Minnesota area police departments. Officers were excluded if they were current smokers, were older than 58 years old or if they had a history of adverse cardiovascular events. The chief of each department was sent a letter of recruitment (Appendix A) to garner interest in the study, gain permission to enter their departments and obtain access to their officers. Initial contact with officers occurred during routine roll-call procedures prior-to or immediately after a scheduled shift. Officers were then sent a recruitment email (Appendix B) with detailed study procedures and contact information. Officers contacted the primary investigator to schedule testing and were given pre-testing instructions prior to their scheduled appointment (Appendix C). They were instructed to arrive at the lab shortly after a period of full rest (i.e. early morning prior to any regular activities) and refrain from any vigorous physical activity within 48 hours of the test and to abstain from food, caffeine, alcohol, and tobacco for at least eight hours prior to the test. This study was approved by the Institutional Review Board.

4.2.2. Consent form

When participants entered the Clinical Exercise Physiology Lab, they were informed of the testing procedures, notified of any risks involved with testing, and provided written, informed consent (IRB# 1505M70201, Appendix D). Participants also completed a lifestyle and occupational survey (Appendix E) created by the researcher, which contained questions about their regular shift and work hours, average sleep hours, exercise habits, and routine job duties. Participants' height and a weight measured via a standard scale were then recorded.

4.2.3. Resting heart rate variability (HRV) and heart rate recovery (HRR) measurement and analyses

Participants were fitted with a Polar heart rate monitor and a Polar s810 wrist computer watch (Polar, Kempele, Finland) which is a validated method of measuring HRV in research settings (Vanderlei et al., 2008). The participant was instructed to lie comfortably on his/her back on the testing table and to relax but not sleep during the 30 minute testing session. They were informed that the researcher would be checking in on them periodically to make sure they remained awake.

Heart rate data from each Polar s810 wrist computer watch (Polar, Kempele, Finland) was uploaded into the Kubios HRV analysis software (Kubios HRV 2.2, Kuopio, Finland) for both the resting test and the VO_{2MAX} test (detailed below). For resting data, a ten-minute sample was taken at a central point of the total data collection time. This allowed for consistency in mean heart rate and allowed adequate time for the participant to fully relax. Average resting HR was recorded for the ten-minute sample of time. HRV data was then pre-processed utilizing Kubios' moderate artifact correction factor. This factor has been validate as an appropriate interpolation method to reduce artifact (Kubios HRV 2.2, Kuopio, Finland). HRV was analyzed using both time-domain and frequency (spectral) domain analyses. Time-domain was analyzed using meanRR (ms), SDNN (ms), RMSSD (ms), NN50, pNN50 (%), HRV Triangular Index, and TINN. Frequency domain was measured in mean power (Hz) using the Fast-Fourier Transformation (FFT) method to analyze high frequency (HF), low frequency (LF), very low frequency (VLF), and LF/HF ratio. For HRR, post-VO_{2MAX} HR was recorded at 30-second intervals for the first two-minutes of active recovery, immediately after voluntary termination of maximal exercise. HR data was then calculated as a percentage of HR-drop over time, or HRR, at 30, 60, 90, and 120 seconds of active, walking recovery.

4.2.4. Hydrostatic weighing

For assessment of body composition, participants were asked to change into a swimsuit or compression clothing, given instruction on the underwater weighing procedures, and asked to enter the underwater weigh tank (temperature ~ 98-102°F). Participants then fully submerged and maximally exhaled, at which point the weight measurement was taken for a continuous two seconds. Following the weight measurement collection, participants were audibly signaled to return to the surface. Participants underwent a series of five to ten trials to ensure maximum validity. Underwater weight data were inspected visually and the data was excluded if artifact error was present. The two lowest body-fat composition values were then averaged.

4.2.5. Maximal aerobic capacity test (VO_{2MAX} test)

After completion of underwater weighing, participants were allowed to change into appropriate exercise attire to perform the VO_{2MAX} test, which was measured by the Medgraphics Ultima gas exchange analysis system (MGC Diagnostics, St. Paul, MN). Gas flow was calibrated using a three-liter syringe prior to testing and the gas sensor was calibrated by using two different gas mixtures, 21% O_2/79% N_2 and 5% CO_2/12% O_2/83% N_2 (MGC Diagnostics, St. Paul, MN). Participants were fitted with a facemask and pneumatachograph for continuous analysis of gases throughout the test. Respiratory volume, rate, and gases were monitored throughout the test via direct spirometry. Heart rate was monitored via a Polar s810 wrist computer (Polar, Kempele, Finland). The Bruce VO_{2MAX} Protocol (Appendix A; Bruce et al., 1973), a standard, maximal aerobic capacity test protocol was performed using a Woodway treadmill (Woodway, Waukesha, WI, USA). Participants were asked to give maximal effort and voluntarily terminated the test upon complete exhaustion. The test was immediately followed by two minutes of active, walking recovery.

4.2.6. Statistical analysis

All data are reported as means ± standard deviations, unless otherwise noted. One-way analysis of variance (ANOVA) was used to examine the effect of shift-time on ANS and cardiovascular health. When the ANOVA was significant, Tukey Post-hoc analysis was used to identify significance between the individual groups. Multiple regression analyses examining the effect of lifestyle and occupational implications on ANS and cardiovascular health was also performed. Alpha level for significance was set at $p < 0.05$. All statistical analyses were performed using IBM SPSS Statistics (Version 24; Armonk, New York, USA).

4.3 Results

Participant demographic information and lifestyle and occupational variables are summarized in Table 1.

Table 1

Demographics, Lifestyle and Occupational Variables by Shift

	Days	Mids	Nights
n (% males)	32 (84.4)	16 (68.8)	16 (87.5)
Age (years)	42.23±7.51	35.40±9.40	36.07±9.00
Height (inches)	70.40±3.14	69.88±3.53	70.59±3.05
Weight (lbs)	198.85±41.73	200.23±41.00	191.25±29.00
Lifestyle and Occupational Variables			
BMI (kg/m^2)	28.04±4.62	28.76±5.37	26.9±3.78
Body fat percentage	22.69±6.74	25.31±8.55	20.88±6.83
Average days/week of exercise	3±2	3±2	3±2
Average sleep/night (hours)	6.65±0.87	6.78±0.95	6.78±0.98
Shift length (hours)	10±2	10±2	10±2
Average overtime hours/week	12.50±6.60	7.00±3.72	5.28±3.67

Note: N=64
All values are expressed as Mean±SD
Days = day-shift officers; Mids = middle-shift officers; Nights = night-shift officers; BMI = body mass index; bpm = beats per minute.

4.3.1. Autonomic nervous system and cardiovascular health differences between shifts

One-way analysis of variance (ANOVA) indicated no differences between shifts on time-domain measures on resting HRV (Mean RR, RMSSD, NN50, pNN50%, HRV Tri Index, TINN (ms) nor in power domain measures (VLF, LF, HF, LF/HF). There were also no significant differences between shift-groups on average RHR, VO_{2MAX}, or HR. Means and standard deviations for ANS and cardiovascular health data across the three shifts are presented in Table 2.

Table 2

Markers for Autonomic Nervous System and Cardiovascular Health between Shifts

	Days	Mids	Nights
N	32	16	16
Heart Rate Variability Indices			
Time Domain			
Mean NN (ms)	1030.31±25.22	967.82±39.11	999.49±35.16
SDNN (ms)	68.82±4.43	63.00±5.67	63.15±6.14
RMSSD (ms)	50.03±4.06	41.60±5.63	45.39±7.12
NN50	133.69±15.60	99.62±24.67	126.38±27.50
pNN50 (%)	23.65±3.00	17.64±4.64	22.16±5.20
HRV Tri Index	20.15±4.14	14.56±1.18	13.98±1.12
TINN (ms)	154.06±19.23	181.15±27.03	173.13±21.11
Frequency Domain (Power, Hz)			
VLF (ms^2)	1634.79±288.66	1862.17±611.96	1261.38±232.43
LF (ms^2)	2294.07±369.79	1946.00±499.32	1927.78±422.59
HF (ms^2)	808.58±138.53	737.51±217.98	898.71±359.62
LF/HF (ms^2)	4.69±0.80	5.55±1.89	4.08±0.91
Cardiovascular Fitness Indices			
Resting Heart Rate	59.58±1.40	63.53±2.58	61.25±1.82
VO_{2MAX} ($ml \cdot O2 \cdot kg^{-1} \cdot min^{-1}$)	40.2±1.52	41.49±1.89	44.28±1.78
HRR post-maximal exercise			
30sec (%-drop)	8.35±0.74	7.47±0.57	8.89±0.80
60sec (%-drop)	16.36±1.20	15.48±1.44	14.89±1.02
90sec (%-drop)	22.54±1.25	21.86±1.89	20.80±1.37
120sec (%-drop)	27.52±1.20	26.43±2.08	26.79±1.55

Note: N = 64
All values are expressed as Mean±SE
Days = day-shift officers; Mids = middle-shift officers; Nights = night-shift officers; ms = milliseconds; NN = normal to normal beats; SD = standard deviation; RMSSD = root mean square successive differences; NN50 = number of adjacent NN intervals differing by more than 50ms; pNN50 = percent of NN50 compared to total amount of NN; HRV Tri = heart rate variability triangular; TINN = triangular interpolation of the NN interval histogram; Hz = hertz; VLF = very low frequency; LF = low frequency; HF = high-frequency; VO_{2MAX} = maximal aerobic capacity; HRR = heart rate recovery

4.3.2. Lifestyle and occupational influences on autonomic nervous system and cardiovascular health

Of the eleven HRV indices and six cardiovascular health indices (reported in Table 2), only two multiple regression models were significant for lifestyle and occupational independent variables (listed in Table 1) as predictors. Exercise days per week positively predicted (β-coefficient = 0.222, t (55) = 2.048, $p < 0.05$) and body fat percentage inversely predicted (β-coefficient = -0.475, t (55) = -3.478, $p < 0.001$) VO_{2MAX} (F (6, 55) = 7.619, $p < 0.001$, R^2 = 0.674). Multiple regression analyses for lifestyle and occupational variable impacts on all time and frequency domain HRV indices, RHR and HRR were non-significant.

4.4 Discussion

The aim of the present study was to determine whether shift-work in police officers impacts ANS function based on HRV indices, in both time and frequency domains, and cardiovascular health determined by RHR, VO_{2MAX}, and HRR. A secondary aim was to understand the relationships between lifestyle and occupational factors on measures of ANS function and cardiovascular health in police officers. For this aim, lifestyle variables including BMI, body fat, exercise habits, and average hours of sleep, as well as occupational variables such as average shift-length and average overtime work-hours were evaluated on their capability to predict HRV, RHR, VO_{2MAX}, and HRR.

Low HRV has been associated with increased mortality and morbidity in diseased individuals (Huikuri et al., 1999), as well as a strong predictor of cardiovascular risk in healthy individuals (Kors et al., 2007; Whitsel et al., 2001). The current study was not able to clearly elucidate the link between officer ANS health, measured by HRV, and certain lifestyle and occupational variables including BMI, body composition, average hours of sleep, exercise, shift-length and overtime hours between Days, Mids and Night-shift officers. Surprisingly, the present study was also not able to predict lifestyle and occupational variables impact on RHR and HRR variables of cardiovascular health. Though we cannot infer causation, the present study did find that days of exercise per week and low body fat, were predictive of VO_{2MAX} values, reaffirming the link between positive lifestyle habits and good cardiorespiratory fitness.

As seen in the general population, sedentary behavior is associated with higher rates of obesity and poorer cardiovascular health (Healy et al., 2011; Katzmarzyk et al., 2009). Previous research has found that officers have higher BMIs on average than non-officers in the general population (Alasagheirin & Grueskin, 2011; Franke et al., 2002; Hartley et al., 2011; Smolander et al., 1984). Specifically, one study found that 40.5% of officers compared with 32.1% of the general population have BMI's >30 kg/m^2 (Hartley et al., 2011). In the present study, officers had BMIs that averaged within the overweight category (25-29.93 kg/m^2). Though there is still associated risk with overweight BMIs, disease outcomes are not quite as severe when compared with obese classifications (Brown et al., 2000; Launer et al., 1994; Rissanen et al., 1990; Visscher et al., 2004).

Although, VO_{2MAX} did not differ between work-shift groups, the Night-shift workers tended to have higher cardiorespiratory fitness than the Day- or Mid-shifters, which was surprising. Our sample of officers had, on average, VO_{2MAX} values within the 50th percentile (or average) for age predicted values. Research indicates that higher cardiorespiratory fitness is associated with better ANS health, reflective in higher HRV (De Meersman, 1993; Hautala et al., 2009; Lee et al., 2002; Mourot et al., 2004). As the present study did not find differences between shift-groups in HRV, one could argue that because our sample of officers were more physically fit, their HRV values were reflective of healthy ANS function. Previous research has indicated the inextricable link between RHR and HRV indices. Though not a primary aim of this research, the current study was also able to determine strong inverse associations between higher HRV and lower RHR. Because cardiorespiratory fitness causes physical adaptations in the heart muscle, including increases in heart muscle size and strength leading to increases in stroke volume, the heart's mechanical work decreases (Bevegård et al., 1963; Ekblom et al., 1968; Gledhill et al., 1994). Thus, chronic aerobic training results in increased vagal modulation of heart rate and subsequent decrease in sympathetic tone and decreased physiological stress on the system as a whole (Hautala et al., 2009). This again suggests that our sample of officers were already fairly physically fit, prior to testing procedures, which resulted in higher HRV and lower RHR on average.

There are several limitations associated with the present study. First, officers who engage in healthy lifestyle behaviors may have been more likely to sign up for a study involving exercise than those who tended to engage in unhealthy lifestyle behaviors. Second, as with any survey, responses are subject to self-report bias and data may skewed. Similarly, though officers were asked to refrain from strenuous exercise within 48 hours of testing and to arrive completely fasted, these directions may not have been strictly followed.

In conclusion, officers who exercise more often have decreases in body fat, which may lead to increases in cardiorespiratory fitness. Lower BMI is associated with lower disease risk and therefore, officers should strive to reach normal range BMI through lifestyle modification. There must be continued focus towards positive lifestyle change, including the adoption of cardiovascular exercise and a healthy diet, to minimize disease risk and early mortality in police officers. Future directions in research should delve further into the physiological variables that may be impacted by lifestyle and occupational variables. This includes, but is not limited to, utilizing validated survey's designed to clearly identify overall sleep quality and the analysis of blood biomarkers that contribute to ANS dysfunction, like pro-inflammatory cytokines. Also, it may be prudent to analyze long term recordings of HRV in officers while on- and off-duty. 24-hour recordings of HRV may provide more useful information regarding understanding sympathovagal balance during normal daily routines versus while at work. We may then understand the larger impact of occupational stressors and their impact on ANS and cardiovascular health.

CHAPTER

5

STUDY TWO

CHAPTER FIVE: Study Two: Physiological Implications of Psychosocial Factors and Occupational Stress in Police Officers

5.1 Introduction

Police officers are often routinely exposed to life threatening situations and experience events involving civilian death, suicide, bloody crime scenes, chemical spills and biohazard exposure, having personal relationships with victims, making violent arrests, and having physical altercations with suspects (Gershon et al., 2002; Komarovskaya et al., 2011; Liberman et al., 2002; Solomon, 1988; Violanti & Aron, 1995). In addition to critical incidents on the job, administrative hierarchies frequently cause a considerable amount of stress, particularly with shift-rotation and scheduling, discrimination, limited advancement opportunities, and scrutiny surrounding internal investigational procedures (Brown & Campbell, 1990; Burke, 1994; Crank & Caldero, 1991; Evans & Coman, 1993; Franke et al., 2002; Liberman et al., 2002; Martelli et al., 1989; Peters et al., 1998; Siegrist & Peter, 1994; Violanti & Aron, 1995).

Occupational stressors combined with work-family balance and personal lifestyle choices like physical inactivity, poor diet, poor sleep and maladaptive coping mechanisms can be detrimental to physical and mental health (Davey et al., 2000; Loo, 1986). Both occupational and lifestyle variables may be directly related to increased cardiovascular morbidities and a higher mortality rate among police than in the general population. Previous research has found that, in comparison with the general population, police officers have a higher incidence of disease and earlier mortality both while in the active work force (Feuer & Rosenman, 1986; Franke et al., 1998; Vena et al., 1986; Violanti et al., 2013; Violanti et al., 1998) and post-retirement (Brandl & Smith, 2013). Compared to the general population, police officers demonstrate higher rates of physiological dysfunction and disease which has been noted in higher rates of hypertension, coronary heart disease and stroke, endothelial dysfunction, atherosclerotic progression, several cancers and have higher levels of pro-inflammatory biomarkers (Feuer & Rosenman, 1986; Forastiere et al., 1994; Gu et al., 2011; Joseph et al., 2009; Joseph et al., 2010; Ramey et al., 2011; Violanti et al., 2006). Consequently, officers also have a higher incidence of mental disturbance including depressive and anxious tendencies, somatization, post-traumatic stress disorder (PTSD), and evidence of burn-out (Burke, 1994; Gershon, et al., 2002; Hartley et al., 2011; Komarovskaya et al., 2011; Liberman et al., 2002; Violanti & Aron, 1995). Physical and mental pathophysiologies in police officers can be attributed to the psychosocial factors involved with police work.

Specifically, psychosocial stress is described as the physiological stress response to perceived demand (physical or emotional) of a situation and the resources (physical or emotional) at their disposal to respond to a given stressor (Anshel, 2000; Anshel et al., 1997; Biggam et al., 1997; Hemmingway & Marmot, 1999). Psychosocial stress may be both acute (e.g., critical incidents) and chronic (e.g., administrative structure, job satisfaction, perceived inequality or discrimination) in nature. Chronic stressors result from either repeated or accumulated, acute incidents with inadequate coping mechanisms or within administrative hierarchies, where officers have high-effort and low-reward (Anshel, 2000; Evans & Coman, 1993; Liberman et al., 2002; Peters et al., 1998; Siegrist & Peter, 1994). Often, the magnitude of psychosocial stress is impacted by one's personal attributes (Anshel, 2000; Tang & Hammontree, 1992), cognitive appraisal (Anshel, 2000, Anshel et al., 1997; Violanti & Aron, 1995), approach or avoidance (repression) focused coping strategies (Anshel, 2000; Elliot, 1999), and finally, social support (Kirkcaldy et al., 1995). Typically, patrol officers experience more psychosocial stress then officers of other ranks (e.g., sergeants, investigators, lieutenants, captains, chiefs) as they have the highest effort and lowest reward among departmental hierarchies.

Psychosocial stress can have broader negative impacts on both job performance, including diminished quality of service to the community, poor work-family balance, and higher rates of suicide, domestic abuse and substance abuse (Davey et al., 2000; Loo, 1986). To our knowledge, no previous study has analyzed the psychosocial implications of police officer work and the physiological impacts they can have on cardiovascular system health. It is important to understand the implications of these interactions, both psychologically and physiologically. It is also important to understand the prevalence of certain psychosocial outcomes and interactions between perceived stressors so that efforts can be made towards mitigating the stressors officers deal with both acutely (daily) and chronically (over the course of their career).

The primary aim of this study was to examine the relationship between psychosocial factors and physiological markers for cardiovascular health among patrol officers (excluded higher rank officers; e.g., sergeants, investigators, lieutenants, captains, chiefs). We hypothesized that higher psychosocial scores (determined by the Police Occupational Stress Survey, *POSS*) for perceived work-stress (perceived inequality and exposure to critical incidents), negative coping strategies, and negative health outcomes (physical, emotional/behavioral and depressive indicators) would be predictive of higher levels of both traditional (blood pressure, total cholesterol, low-density lipoprotein (LDL) levels, triglycerides, serum cortisol concentrations) and non-traditional markers (C-reactive protein (CRP), Interleukin-6 (IL-6), Interleukin-1 Beta (IL-1β) and Tumor Necrosis Factor alpha (TNFα)) for cardiovascular health. Further, that higher administrative support, job satisfaction, and positive coping mechanism scores would be inversely related to lower traditional and non-traditional markers for cardiovascular health.

5.2 Methods

5.2.1. Recruitment and scheduling

One hundred and sixteen officers were recruited from local Minneapolis-St. Paul Metropolitan Police Departments. There was no exclusion criteria. Each police chief was sent an official letter of recruitment to obtain permission to enter their facility and work with their officers (Appendix E). Initial contact was made at each department's mandatory, pre-shift roll-call at the start of each shift (day: 0600-0800; middle: 1200-1400; and nighttime: 1800-2000). Officers then self-selected to participate and could either sign-up in person or contact the researcher via email to indicate interest. After which, officers were sent study details and pre-testing information procedures (Appendix F) in preparation for data collection. Officers were instructed to report to their department of work at the agreed upon time after fasting from food, caffeine, alcohol and tobacco for at least eight hours prior to data collection. Upon arrival to their department of work, officers were consented (IRB #00001584, Appendix G) and informed of data collection procedures (detailed below).

5.2.2. Blood pressure

Participants sat comfortably for ten minutes prior to the blood pressure assessment. Participants were then fitted with an appropriately sized blood pressure cuff on their right upper arm, just superior to the antecubital fossa. Using a stethoscope on the participant's brachial artery, the researcher rapidly inflated the blood pressure cuff to 220 mmHg, moderately releasing pressure until both systolic and diastolic Korotkoff sounds were assessed.

5.2.3. Blood sample collection and storage

Antecubital venipuncture was used to collect 8mL of eight-hour fasting blood samples. Of which, 3mL was collected in lithium heparin tubes for blood lipid concentrations and 5mL was collected in anticoagulant, serum-separator tubes for cortisol, IL-1β, IL-6, TNFα, and CRP. Within an hour of collection, blood collection tubes were centrifuged at 3000 RPM (1500G) at 4°C for 15 minutes to separate blood cells from plasma and serum, respectively. Plasma and serum was then pipetted into Eppendorf tubes and stored at -80°C until future analysis.

5.2.4. Blood biomarker analysis

Plasma specimen were assessed for fasting total cholesterol (polychromatic endpoint), calculated LDL cholesterol (Total Cholesterol-HDL-triglycerides/5), HDL cholesterol, Non-HDL cholesterol, and triglycerides (bichromatic end point) (Dimension Vista 1500 Intelligent Lab System, Siemens Medical Solutions USA, Inc., Tarrytown, NY). Serum concentrations for cortisol were analyzed via direct chemiluminescent assay (ADVIA Centaur XP Immunoassay System, Siemens Medical Solutions USA, Inc., Tarrytown, NY) using standardized procedures.

Serum IL-1β, IL-6, and TNFα concentrations were measured using a high-sensitivity multiplex magnetic, color-coded beads pre-coated with anti-human antibody for each respective cytokine (R&D Systems, Minneapolis, MN). After incubation, and washing, biotinylated anti-human detection antibody was added followed by phycoerythrin-conjugated streptavidin via Luminex instrument analysis (Bio-Plex 200, Bio-Rad Laboratories, Inc., Hercules, CA). Samples were run in duplicate and values were interpolated from 5-parameter fitted standard curves generated on each 96-well plate

Serum CRP concentrations were measured using a high-sensitivity quantitative sandwich enzyme linked immunosorbent assay (ELISA) in 96-well microtiter plates (R&D Systems, Minneapolis, MN). Each well was pre-coated with a CRP detection antibody. Standards, samples and controls were then pipetted into the wells. After incubation, the plate was washed and an enzyme-linked conjugate was added. Then the plate was washed again and a substrate solution was added. The color development was then stopped and the intensity of the absorbance was measured on a microtiter plate reader (Epoch Microplate Spectrophotometer, Biotek Instruments, Winooski, VT). Samples were measured in duplicate and fit to a standard curve.

5.2.5.Police Occupational Stress Survey (POSS)

The survey used for this study (Appendix I) was adapted from a previously utilized survey that assesses common sources of stressors police officers face in their occupation and corresponding adverse health outcomes (Gershon et al., 2002). Officers were asked to rate each item on a Likert-type scale (e.g., “strongly agree” to “strongly disagree). This extensive 126-item instrument included questions regarding both demographic information and psychosocial factors on four major constructs: Perceived sources of occupational stress, personal outlook, coping mechanisms, and health outcomes. Sources of occupational stress were grouped into the following four categories: (1) Administrative support (e.g., the administration supports officers who are in trouble, I can trust my work partner), (2) perceived inequality (e.g., the department tends to be more lenient in enforcing rules and regulations for female officers; I feel that I am less likely to get chosen for a promotion because of “who I am”), (3) critical incidents (e.g., shooting someone in the line of duty; making a violent arrest; personally knowing a victim), and (4) job satisfaction (e.g., I have accomplished many worthwhile things in my career). Personality factors, categorized as personal outlook, included one category of items relating to officer personal beliefs and social interactions affected by their occupation (e.g., my beliefs about my personal safety, spirituality, outlook, have been changed by my perspectives at work; I feel like I treat the public as if they were impersonal objects). Coping mechanisms included two sub-categories: (1) Positive coping mechanisms (e.g., pray for guidance and strength; exercise regularly to reduce tension); and (2) negative coping mechanisms including both avoidance strategies (e.g., try to act as if nothing is bothering you; stay away from everyone, you want to be alone) and negative behaviors (e.g., how often do you let your feelings out by smashing, breaking, or punching things; how often do you drink more than you planned; how often do you use tobacco/smoke more to help you relax). Finally, health outcomes were grouped into: (1) Physical health outcomes (e.g., do you suffer from: migraines, high-blood pressure, low back pain), (2) emotional/behavioral symptoms (e.g., how often: do you have feelings of being trapped or caught, do you feel like you have a lump in your throat, do you crying easily) (3) depressive tendencies (e.g., I want to withdraw from the constant demands on my time and energy from work; I have difficulty concentrating on my job; I feel negative, futile, or depressed about work).

The *POSS* was scored and coded according to prior methods and all scales have been previously validated (Gerson et al., 2002). Global scores in each of sub-scale were scored individually and averaged for the total sample of officers. In addition, scores for specific items within certain sub-scales were also scored individually and analyzed for prevalence within our sample of officers.

5.2.6. Data analysis

All data are reported as means ± standard deviations. Height and weight were used to calculate body mass index (BMI, kg/m^2). Prevalence statistics were calculated using all officer data (N=116), however multiple regression analyses, including the *POSS* sub-scales and physiological markers, were evaluated only among patrol officers (N=87). Alpha level for significance was set at $p < 0.05$. All statistical analyses were performed using IBM SPSS Statistics (Version 25; Armonk, New York, USA).

5.3 Results

Participant demographic information is presented in Table 1.

Table 1

Participant Demographic Information

	All Officers	Patrol Officer	Sergeant	Investigator/ Detective	Lieutenant or higher
n (males, %)	116 (81.9)	87 (79.3)	17 (94.1)	5 (60.0)	7 (100)
Age (yrs)	37.18±8.72	34.65±7.83	43.80±6.64	39.41±2.22	50.91±5.53
Height (in)	71.46±11.88	72.07±13.56	69.21±5.19	67.80±3.49	70.57±2.37
Weight (lbs)	195.22±49.13	193.84±49.33	203.12±56.69	174.20±28.33	208.14±43.75
BMI (kg/m^2)	27.89±6.35	27.68±6.76	29.29±5.74	26.53±2.23	29.24±4.82
Y of Service	11.01±8.77	8.08±7.19	18.56±7.03	14.70±5.38	26.43±4.61

	All Officers	
	n	%
Race		
African American	5	4.31
Asian	5	4.31
Caucasian	101	87.07
Hispanic	4	3.45
Other	1	0.86
Education		
Some College	4	3.4
College	95	81.9
Graduate School	17	14.7
Prior Military Service	19	16.38
Shift		
Day	62	53.45
Mid	28	24.14
Night	25	21.55
Marital Status		
Single	22	18.97
Live-in Partner	17	14.66
Married	70	60.34
Divorced/Separated	6	5.17
Kids at Home	64	55.17

Note: N = 116
BMI = body mass index; Y = years

5.3.1. Psychosocial factor prevalence in police officers

Prevalence, and corresponding emotional impact, for officers with exposure to critical incidents over the course of their career, are shown in Table 2.

Table 2

Emotional Impact with Exposure to Critical Incidents – All Officer Rankings

Type of Incident	**Exposure to Critical Incidents**		**Moderate to High Emotional Impact**
	n	%	%
Attending a police funeral	103	88.8	94.2
Being the subject of an internal investigation	73	62.9	93.2
Experiencing a needle stick or other exposure to blood/body fluids	80	69.0	81.3
Personally knowing a victim	68	58.6	80.9
Shooting someone in the line of duty	14	12.1	64.3
Responding to a bloody crime scene	110	94.8	60.0
Making a violent arrest	114	98.3	57.9
Being involved in a hostage situation	36	31.0	52.8
Responding to a call related to a chemical spill/gas leak	63	54.3	20.6

Note: N=116

In conjunction with experiencing critical incidents on the job, over the course of their careers, many officers have endured periods of post-traumatic stress disorder (PTSD) in some way. Specifically, 34.6% of officers have had intrusive or recurrent distressing thoughts, memories or dreams about the event, 25% of officers have avoided things surrounding the event (thoughts, conversations, places, etc.) and 26% have felt detached from people and activities that are important to them due to a traumatic experience. Analysis of officer sources of occupational stress revealed that 61.5% of officers feel that there is good cooperation among department units and 91.4% feel that they can trust their work partner. However, only 31.7% feel that promotional opportunities are tied to merit and only 19.2% believe that their administration supports officers who are in trouble. The majority of officers still view their work as a career (64.4%) and feel that they have accomplished many worthwhile things during their time of service (75%). The majority of officers (80.8%) also feel that they can obtain stress-debriefing when they need it, although there is still evidence of burnout (29.8%). With the current media scrutiny in American society, 79.8% of officers feel that media reports are biased against the police force.

5.3.2. Physiological outcomes and psychosocial factors

According to established disease risk stratification for CRP, 28.1% of patrol officers were categorized as having high risk (>3 mg/L), 31.1% as moderate risk (1-3 mg/L), while the remaining 40.8% were low risk (<1 mg/L). Compiled physiological data for traditional and non-traditional markers for cardiovascular health in patrol officers (N=87) is presented in Table 3.

Table 3

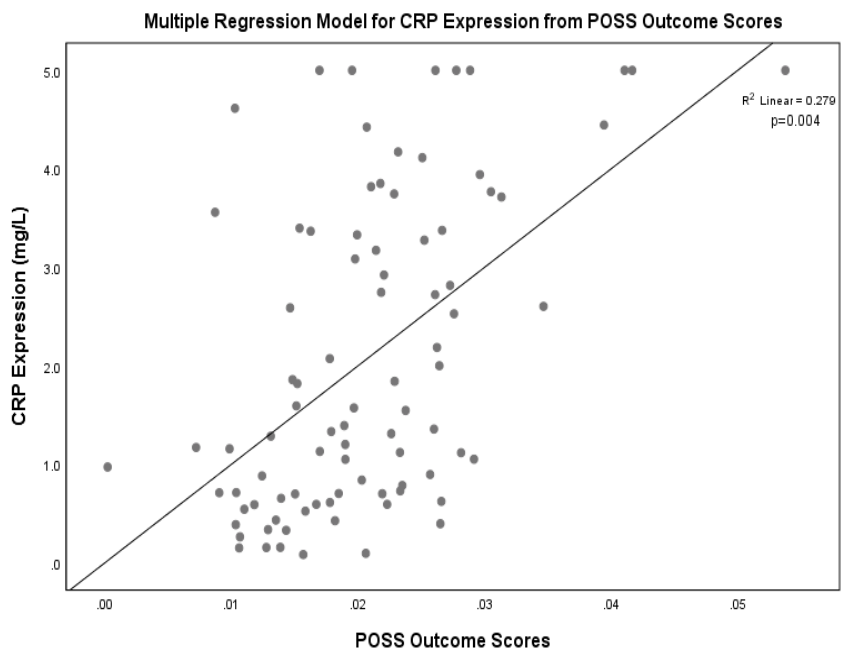
Traditional and Non-traditional Physiological Measures of Cardiovascular Health

	Mean±StDev	**Range**	**At Risk Values**
Traditional Biomarkers			
Systolic Blood Pressure (mmHg)	126.09±14.97	92-160	>120
Diastolic Blood Pressure (mmHg)	84.51±11.14	62-110	>80
Total Cholesterol (mg/dL)	188.24±43.40	88-319	>200
HDL Cholesterol (mg/dL)	51.24±16.75	23-103	Males <40 Females < 50
LDL Cholesterol (mg/dL)	112.48±37.34	25-223	>100
Non-HDL Cholesterol (mg/dL)	136.99±43.45	47-276	>130
Triglycerides (mg/dL)	126.98±103.15	29-737	>150
Cortisol (ug/dL)	14.13±5.29	3.50-31.30	>22
Non-traditional Biomarkers			
CRP (mg/L)	2.06±1.58	0.08-5.00	>1
IL-1β (pg/mL)	0.06±0.09	0.00-0.48	>1
IL-6 (pg/mL)	0.76±0.97	0.00-4.34	>3
TNFα (pg/mL)	5.52±2.51	0.16-13.85	>8.8

Note: N=87
HDL = high-density lipoprotein; LDL = low-density lipoprotein; CRP = C-reactive protein; IL-1β = interleukin-1 beta; IL-6 = interleukin-6; TNFα = tumor necrosis factor alpha

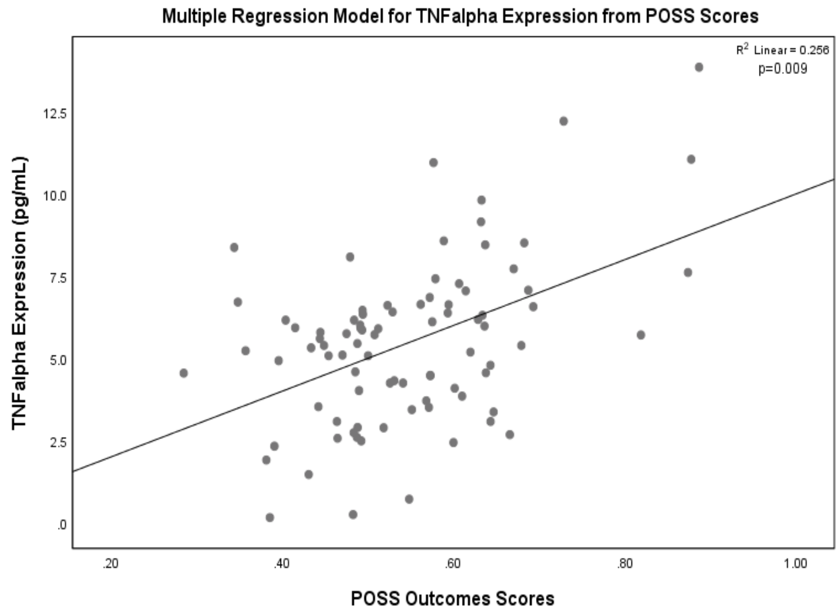
Of the ten *POSS* sub-scales (administrative support, perceived inequality at work, exposure to critical incidents, job satisfaction, personal outlook, positive coping mechanisms, negative coping mechanisms, negative physical health outcomes, emotional and behavioral indicators, and depressive tendencies), only three of the twelve multiple regression models for traditional and non-traditional physiological biomarkers (listed in Table 3 above) were significant. *POSS* sub-scales for perceived inequality at work (β-coefficient = 0.434, t (76) = 3.809, $p < 0.001$) and negative emotional/behavioral indicators (β-coefficient = 0.287, t (76) = 2.165, $p < 0.05$) positively predicted CRP expression (F (10, 76) = 2.941, $p = 0.004$, $R^2 = .279$, $p < 0.05$; shown in Figure 1). The *POSS* sub-scale for negative physical health outcomes nearly reached significance in positively predicting CRP expression (β-coefficient = 0.231, t (76) = 1.927, $p = 0.058$).

Figure 1



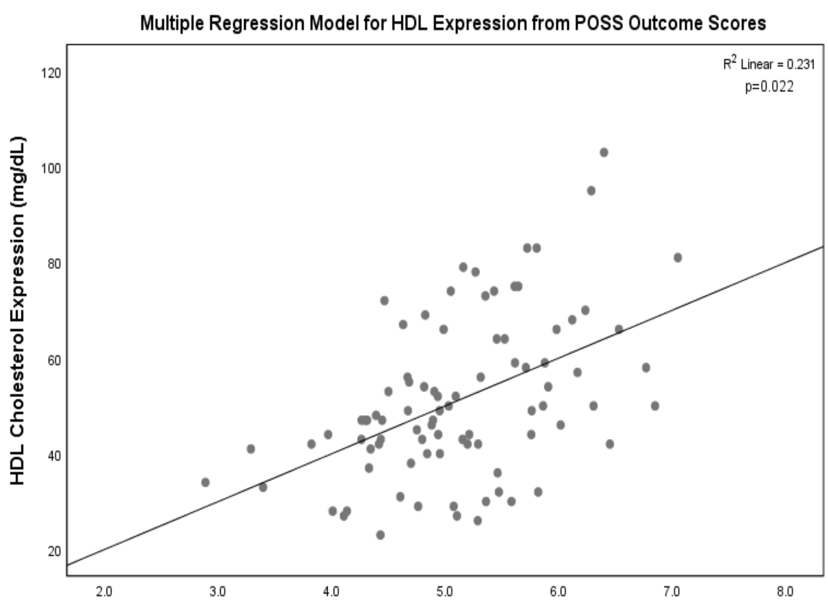
The multiple regression model for the *POSS* sub-scale for perceived inequality at work (β-coefficient = 0.433, t (76) = 3.735, $p < 0.001$) and negative physical health outcomes (β-coefficient = 0.266, t (76) = 2.187, $p < 0.05$) positively predicted TNFα expression (F (10, 76) = 2.617, $p = 0.009$, $R^2 = .256$, $p < 0.05$; shown in Figure 2).

Figure 2



POSS sub-scales did not significantly predict IL-6 and IL-1β expression. However, the model for HDL cholesterol expression was significant (F (10, 76) = 2.278, $p = 0.022$, $R^2 = .231$, $p < 0.05$; shown in Figure 3).

Figure 3



Negative physical health scores from the *POSS* were inversely predictive of HDL cholesterol expression (β-coefficient = -0.420, t (76) = -3.398, $p < 0.001$). The *POSS* was did not significantly predict any of the other traditional markers, including systolic and diastolic blood pressure, total cholesterol, LDL cholesterol, triglycerides and cortisol.

5.4 Discussion

The primary aim of the present study was to examine the prevalence of psychosocial factors that officers face and the relationship between psychosocial factors and physiological markers for cardiovascular health. When analyzing specific items and sub-scales of the *POSS,* a large majority of officers have been exposed to a high amount of critical incidents while on the job and have experienced moderate to high emotional distress as a result. Results indicated that roughly a third of officers currently, or have previously, experienced symptoms of PTSD regarding traumatic experiences on the job. However, as in prior research, the current study found that sources of perceived work stress in police officers may come more from administrative sources, like perceived inequalities at work, and not exposure to critical incidents (Brown & Campbell, 1990; Burke, 1994; Evans & Coman, 1993; Franke et al., 2002; Gerson et al., 2002; Liberman et al., 2002; Violanti & Aron, 1995). This finding may be due to administration to officer role-disconnect, mistrust in internal investigation procedures, discrimination, policy decisions made without appropriate communication or lack of control in shift-rotation schedules. The majority of officers feel there is good cooperation and trust among fellow patrol officers and have positive outlooks on their profession. However, even though the majority of officers feel they have access to appropriate stress-debriefing resources should they need it, there is still evidence of PTSD and symptoms of burnout. Therefore, officers may have access to these mental health resources but may also be underutilizing them.

The current study found evidence to suggest that both traditional and non-traditional measures of cardiovascular health are elevated in officers and may be predicted by scores from the *POSS*. Only one other study has analyzed the effect of officer perceived occupational stress on physiological biomarkers of cardiovascular health, specific to positive associations between job demand (high-effort/low-reward) and IL-6 and IL-1β expression (Franke et al., 2010). In our entire sample of officers, just over 25% of officers showed CRP expression consistent with high-risk disease profiles and separately, around 30% had moderate risk classification for CRP expression. High levels of CRP have been shown in previous research to be an indicator of negative cardiovascular risk profiles, dysregulated autonomic nervous system function and other diseased states (Bellone et al., 2006; Dowlati et al., 2010; Festa et al., 2000; Haverkate et al., 1997; Koenig et al., 1999; Lampert et al., 2008; Locksley et al., 2001; McCanlies et al., 2011; Ridker et al., 2000a; Swardfager et al., 2010; Visser et al., 1999; Yudkin et al., 1999). Higher CRP expression may be indicative of consistent widespread inflammation within police officers which can lead to decrements in immune system function and higher rates of disease. This evidence furthers the argument that early officer mortality may be due to chronically high systemic inflammation.

Further, both perceived inequities at work and adverse physical health outcomes were strong predictors of TNFα expression, lending to the argument that pro-inflammatory cytokines and negative mental and physical health decrements are positively associated. However, with the exception of HDL cholesterol, all other non-traditional and traditional biomarkers for cardiovascular health were not predicted by *POSS* sub-scales.

Potential limitations of the present research include inherent self-report inaccuracies within *POSS* scales. Most of the items were very personal in nature and may have made officers feel emotionally exposed or uncomfortable. Perhaps, given the sensitive nature of the survey, they felt that answering with complete honesty may put their careers in danger if confidentiality were breached and personal information was shared with third parties. Also, given the extent of our survey, survey-fatigue may have been present.

Further directions for research among police officers may include the analysis of shift-call logs regarding the volume, magnitude, and types of calls that officers respond to throughout the course of a single year. Examination of the amount of high-risk calls compared to routine-duty calls that officers respond to each year in relation to physiological markers of stress and

POSS sub-scales, may give us further insight into officer workload and critical incident exposure. Also, the *POSS* is fairly broad in regards to critical incident exposure and symptoms of PTSD. Futhermore, these items did not specify a time frame but merely asked whether officers had been exposed to certain high-risk incidents or had ever felt certain emotional impact regarding a critical incident. Therefore, with no attached time-context, future research could elucidate the emotional backlash of police work on a consistent basis to understand when and where mental health resources and stress debriefing protocols would be best implemented.

In conclusion, these results suggest that officers may be under-utilizing positive coping mechanisms, like exercise or mental/emotional health resources, to cope with perceived work stress. By underutilizing positive coping mechanisms, negative emotional consequences may lead to higher expression of certain physiological biomarkers. Proper interventions are needed to address both acute and chronic occupational stressors in order to prevent poor physiological states which may lead to increased rates of disease in the future. Given that police mortality statistics are higher than any other private sector occupation (Calvert et al., 1999; Tiesman et al., 2013), this research may fill gaps in the literature about causal relationships between negative psychosocial impacts of police work and the resulting physiological dysfunction that can result in earlier disease and death.

CHAPTER

6

STUDY THREE

CHAPTER SIX: Study Three: Impacts of Shift-Work and Sleep on Physiological Markers of Cardiovascular Health in Police Officers

6.1 Introduction

Police officers have a higher incidence of disease and early mortality than the normal population. This is evidenced by higher rates of physiological dysfunction and disease noted in endothelial dysfunction (Joseph et al., 2010; Violanti et al., 2006) and atherosclerotic progression (Feuer & Rosenman, 1986; Joseph et al., 2009), hypertension, (Pyörälä et al., 2000a), coronary heart disease and stroke (Pyörälä et al., 2000b), various cancers (Forastiere et al., 1994; Gu et al., 2011) and higher levels of pro-inflammatory biomarkers (Ramey et al., 2011) when compared to the general population. Consequently, compared to the general population, officers also have a higher incidence of mental disorders including anxiety, depression, somatization, post-traumatic stress disorder (PTSD), and symptoms of burn-out (Gershon et al., 2002; Hartley et al., 2011; Hartley et al., 2012; Komarovskaya et al., 2011; Liberman et al., 2002; Violanti & Aron, 1995).

One specific issue officers deal with throughout the course of their careers are constant shift-work rotations, changing schedules, and forced overtime (Violanti & Aron, 1994). Often, officers are required to rotate from day-shift, to middle-shift to night-shift hours every three to six months. These rotations are based on departmental, administrative decisions and are outside of the officer’s control. Previous data has shown that dysregulated sleep leads to decreased concentration and productivity at work, chronic fatigue, absenteeism, injury on the job, and circadian rhythm disturbance, among other clinical health outcomes (Brugère, Barrit, Butat, Cosset, & Volkoff, 1997; Charles et al., 2007; Fekedulegn et al., 2013; Neylan et al., 2002; Rajaratnam, et al., 2011; Vgontzas et al., 2004; Vila, 2006; Vila & Kenney, 2002; Violanti et al., 2012).

These adverse clinical health outcomes include evidence of various cardiovascular comorbidities such as hypertension and stroke (Kawachi et al., 1995; Knutsson et al., 1986; Morikawa et al., 1999) and metabolic diseases such as obesity, type II diabetes, metabolic syndrome and various gastrointestinal disorders (Karlsson et al., 2003; Niedhammer et al., 1996; Sookoian et al., 2007; Van Amelsvoort et al., 1999; Violanti et al., 2009). Shift-work has also been shown to lead to higher rates of mental disorders like depression (Scott et al., 1997); however, not all studies have shown consistent results between shift-work and higher rates of depression (Goodrich & Weaver, 1998). Other mental and emotional problems have also been noted in conjunction with shift-work including higher rates of perceived stress, poor coping mechanisms like excessive alcohol/tobacco use, poor social support (Gordon et al., 1986), and diminished self-esteem and locus of control (Healy et al., 1993). In fact, research suggests that shift-work, and more specifically, working overnights, has detrimental effects on family life and on social support and satisfaction (Bohle & Tilley, 1989; Colligan & Rosa, 1990).

Concurrently, shift-work has also been associated with autonomic dysfunction shown in decreased heart rate variability (HRV) both on (Furlan et al., 2000; Järvelin-Pasanen et al., 2013) and off-duty (Holmes et al., 2001; Su et al., 2008; Van Amelsvoort et al., 2000) and with increased pro-inflammatory cytokine and cortisol production (Puttonen et al., 2011; Redwine et al., 2000; Sookoian et al., 2007; Vgontzas et al., 2004; Yamasaki et al., 1998). To our knowledge, no previous research has investigated the effect of shift-work on indices of sleep quality and stress-biomarker expression in police officers. It is important to understand this connection as officers have multi-annual shift changes and often switch from diurnal to nocturnal sleep schedules frequently throughout the year. These changes in sleep patterns can negatively impact their physical health and cognitive function, and thereby negatively impact the communities they serve.

The primary aim of this study was to determine the influence of shift-work on both non-traditional and traditional markers of cardiovascular health among police officers. We hypothesized that Night-shift officers (Nights: work 10-12 hour shifts starting between 1800 and 2000 until 0500 and 0800) would exhibit greater expression of both non-traditional (C-reactive protein (CRP), Interleukin-6 (IL-6), Interleukin-1 Beta (IL-1β) and Tumor Necrosis Factor-alpha

(TNFα)) and traditional markers (body mass index (BMI), blood pressure, blood lipids, and cortisol) of cardiovascular health when compared to Day- or Mid-shift officers (Days: work 10-12 hour shifts starting between 0500 and 0700 until between 1600 and 1800; Mids: work 10-12 hour shifts starting between 1200 and 1400 until between 0000 and 0300).

In addition, our secondary aim was to examine the relationship between shift-work and the Pittsburgh Sleep Quality Index (*PSQI*) indices. We hypothesized that Night-shift officers would have higher scores on the *PSQI* and its sub-scales (higher scales are indicative of poorer sleep) than Day- or Mid-shifters.

6.2 Methods

6.2.1. Recruitment and scheduling

Eighty-seven officers recruited from local Minneapolis-St. Paul Metropolitan Police Departments completed the study. There was no exclusion criteria. Initial contact was made with each department's chief (Appendix E) to obtain permission to enter each department for data collection. The study was described to the officers who self-selected to participate. They could either sign-up for data collection in person or contact the researcher via email to indicate interest. Interested officers were sent study details (Appendix F) and pre-testing information procedures in preparation for data collection. Officers were instructed to report to their department of work at the agreed upon time completely fasted from food, caffeine, alcohol and tobacco for at least eight hours prior to data collection. Upon arrival to their department of work, officers provided written, informed consent (IRB # 00001584, Appendix G).

6.2.2. Blood pressure

Participants sat in a comfortable position for ten minutes prior to the blood pressure assessment. An appropriately sized blood pressure cuff was placed on the upper right arm, just superior to the antecubital fossa. Using a stethoscope on the participant's brachial artery and a sphygmomanometer, the researcher rapidly inflated the blood pressure cuff to 220 mmHg.

Pressure was then slowly released until both systolic and diastolic Korotkoff sounds were assessed.

6.2.3. Blood biomarker collection and analysis

Fasting blood samples were collected in 5mL anticoagulant, serum-separator tubes for cortisol, IL-1β, IL-6, TNFα, and CRP and in 3mL lithium heparin tubes for blood lipids (cholesterol, HDL, LDL and Non-HDL cholesterol, and triglycerides). Blood collection tubes were then centrifuged, within an hour of data collection at 3000 RPM (1500G) at 4°C for 15 minutes to separate blood cells from serum/plasma which was then pipetted into separate aliquots. Aliquots were stored at -80°C until future analysis.

Serum concentrations for cortisol were analyzed via direct chemiluminescent assay (ADVIA Centaur XP Immunoassay System, Siemens Medical Solutions USA, Inc., Tarrytown, NY) using standardized procedures. Serum IL-1β, IL-6, and TNFα concentrations were measured using a high-sensitivity multiplex magnetic, color-coded beads pre-coated with anti-human antibody for each respective cytokine (R&D Systems, Minneapolis, MN). After incubation, and washing, biotinylated anti-human detection antibody was added followed by phycoerythrin-conjugated streptavidin via Luminex instrument analysis (Bio-Plex 200, Bio-Rad Laboratories, Inc., Hercules, CA). Samples were run in duplicate and values were interpolated from 5-parameter fitted standard curves generated on each 96-well plate

Serum CRP concentrations were measured using a high-sensitivity quantitative sandwich enzyme linked immunosorbent assay (ELISA) in 96-well microtiter plates (R&D Systems, Minneapolis, MN). Each well was pre-coated with a CRP detection antibody. Standards, samples and controls were then pipetted into the wells. After incubation, the plate was washed and an enzyme-linked conjugate was added. After incubation, the plate was washed and a substrate solution was added. The color development was then stopped and the intensity of the absorbance was measured on a microtiter plate reader (Epoch Microplate Spectrophotometer, Biotek

Instruments, Winooski, VT). The values were interpolated from a log-log fitted standard curve. Each sample was analyzed using duplicate measures.

Plasma specimens were assessed for traditional markers of cardiovascular health which included fasting total cholesterol (polychromatic endpoint), using calculated low-density lipoprotein (LDL) cholesterol (Total Cholesterol-HDL-triglycerides/5), high density lipoprotein (HDL) cholesterol, Non-HDL cholesterol, and triglycerides (bichromatic end point; Dimension Vista 1500 Intelligent Lab System, Siemens Medical Solutions USA, Inc., Tarrytown, NY).

6.2.4. Pittsburgh Sleep Quality Index (PSQI)

The *PSQI* (Appendix H) examines sleep quality, measured on a 5-point Likert scale, across seven areas of sleep. These sub-scales assess: (1) subjective sleep quality, (2) sleep latency, (3) sleep duration, (4) habitual sleep efficiency, (5) sleep disturbances, (6) use of sleep medication and (7) daytime dysfunction during the previous month. In addition to scores on these seven sub-scales, a global score was totaled. Studies indicate good internal consistency, reliability and validity for this scale (Buysse et al., 1989).

6.2.5. Data analysis

All data are reported as means ± standard deviation. Alpha level for significance was set at $p < 0.05$. One-way analysis of variance (ANOVA) was utilized to determine differences between shift-work (Days, Mids, and Nights) in physiological biomarker expression, traditional markers of cardiovascular health, and *PSQI* scores. When the ANOVA F-statistic was significant, Tukey Post-hoc analysis was used to identify between which groups significance occurred. Pearson correlation analyses was used to analyze relationships between sleep quality indices and physiological biomarker expression. All statistical analyses were performed using IBM SPSS Statistics (Version 25) (Armonk, New York, USA).

6.3 Results

Participant demographics are detailed in Table 1.

Table 1

Participant Demographic Information

	Days	Mids	Nights	All Officers
n	41	27	19	87
Age	37.16±8.49	32.65±7.36	32.08±5.19	34.65±7.83
Years of Service	10.61±8.16	5.37±5.53	6.49±5.17	72.07±13.56
Height (inches)	69.67±3.85	68.94±3.57	70.79±3.88	193.84±49.33
Weight (lbs)	201.54±47.13	186.48±35.13	209.11±45.72	27.68±6.76
BMI (kg/m^2)	28.99±5.12	27.55±4.12	29.20±5.23	8.08±7.19

	All Officers	
	n	%
Sex		
Males	69	59.48
Females	18	15.52
Race		
African American	5	4.31
Asian	5	4.31
Caucasian	72	62.07
Hispanic	4	3.45
Other	1	0.86
Education		
Some College	3	2.59
College	76	65.52
Graduate School	8	6.90
Prior Military Service	14	12.07
Marital Status		
Single	18	15.52
Live in partner	17	14.66
Married	48	41.38
Divorced/Separated	3	2.59
Kids at home	43	37.07

Note: N = 87
Days = day-shift officers; Mids = middle-shift officers; Nights = night-shift officers; BMI = body mass index

6.3.1. Differences between work-shifts and physiological biomarker expression

One-way analysis of variance (ANOVA) showed a statistically significant difference in cortisol expression for the three work-shift groups: (F (2, 84) = 7.653, $p<0.001$) with TNFα expression trending toward significance (F (2, 84) = 2.691, $p = 0.074$). Post-hoc comparisons using the Tukey HSD test indicated that the mean scores for cortisol expression between Days (M = 16.28, SD = 4.14) was significantly higher than Mids (12.67±5.50, $p = 0.011$) and Nights (11.57±5.59, $p = 0.003$). However, cortisol expression for officers on Mids did not differ significantly from Nights ($p = 0.738$). All other non-traditional cardiovascular health biomarkers did not differ significantly between groups.

One-way ANOVA for traditional markers of cardiovascular health indicated that only total cholesterol between shifts showed a statistically significant difference (F (2, 84) = 3.729, $p = 0.028$), with Post Hoc Tukey HSD analyses revealing that day-shift officers (197.63±39.83) had significantly ($p = 0.021$) higher levels of total cholesterol than night-shift officers (165.85±44.38). However no differences in total cholesterol were found between officers working Mids and Days, nor Mids and Nights. There were no other traditional cardiovascular markers of significance between shifts. All physiological biomarker expression by work-shift are listed in Table 2.

Table 2

Non-traditional and Traditional Markers of Cardiovascular Health by Work-Shift

	Days	**Mids**	**Nights**	**At Risk**
n	41	27	19	**Values**
Non-traditional Markers				
CRP (mg/L)	1.94±1.43	2.29±1.73	1.96±1.70	> 1
IL-1β (pg/mL)	0.07±0.10	0.06±0.11	0.03±0.05	> 1
IL-6 (pg/mL)	0.70±0.89	0.80±1.02	0.82±1.10	> 1
TNFα (pg/mL)	4.96±2.32	6.37±2.60	5.54±2.57	> 8.8
Traditional Markers				
BMI (kg/m^2)	28.99±5.12	27.55±4.12	29.20±5.23	> 24.9
Systolic BP (mmHg)	126±15	126±18	127±12	> 120
Diastolic BP (mmHg)	85±11	84±12	84±10	> 80
Total Chol. (mg/dL)	197.63±39.83	189.74±43.80	165.84±44.38	> 200
HDL Chol. (mg/dL)	50.29±18.99	51.67±13.82	52.68±16.07	< 40 males < 50 females
LDL Chol. (mg/dL)	119.93±35.37	117.33±36.35	88.67±35.06	> 100
Non-HDL Chol. (mg/dL)	147.37±41.09	137.93±41.49	113.26±44.03	>130
Triglycerides (mg/dL)	142.07±100.58	103.33±44.43	128.00±155.38	> 150
Cortisol (ug/dL)	16.28±4.14	12.67±5.50	11.57±5.59	> 22

Note: N=87
Days = day-shift officers; Mids = middle-shift officers; Nights = night-shift officers; CRP = C-reactive protein; IL-1β = interleukin-1 Beta; IL-6 = interleukin-6; TNFα = tumor necrosis factor alpha; BMI = body mass index; BP = blood pressure; HDL = high-density lipoprotein; LDL = low-density lipoprotein; Chol. = cholesterol

6.3.2. Sleep quality differences between shift-work groups

One-way ANOVA for *PSQI* scores showed that daytime dysfunction was significantly different between work-shift groups (F (2, 84) = 4.776, $p = 0.011$). Tukey HSD post-hoc analysis indicated that mid-shift workers had a significantly lower daytime dysfunction (0.63±0.56) than night-shift officers (1.21±0.71), $p = 0.008$). However, differences between day-shift (0.80±0.64) and night-shift (1.21±0.71) officers only approached significance ($p = 0.061$) for higher daytime dysfunction among night-shifters. Interestingly, sleep duration, quality, disturbance, efficiency and latency, use of sleep medication, and global *PSQI* scores did not differ between shifts-groups (see Table 3 for *PSQI* scores between shift-groups).

Table 3

PSQI Scores According to Work-Shift

	Days	**Mids**	**Nights**
n	41	27	19
SubjSlpQ	1.20±0.71	1.26±0.59	1.32±0.58
SlpLaten	1.12±0.93	1.56±0.97	1.26±0.99
SlpDur	1.46±1.00	1.33±1.00	1.47±0.90
SlpEff	0.39±0.67	0.22±0.51	0.21±0.42
SlpDistb	1.41±0.50	1.22±0.51	1.21±0.42
Meds	0.34±0.76	0.41±0.93	0.74±1.19
DayDys	0.80±0.64	0.63±0.56	1.21±0.71
Global Sleep	6.73±2.79	6.63±2.99	7.42±2.73

Note: N=87
Days = day-shift officers; Mids = middle-shift officers; Nights = night-shift officers; SubjSlpQ = subjective sleep quality; SlpLaten = sleep latency; SlpDur = sleep duration; SlpEff = sleep efficincy; SlpDistb = sleep disturbance; Meds = use of sleep medication; DayDys = daytime dysfunction

6.4 Discussion

The primary aim of the present study was to understand the differences in both traditional (blood pressure, cholesterol, cortisol) and non-traditional (pro-inflammatory cytokines) biomarkers for cardiovascular health between Day-, Mid-, and Night-shift police officers. We also examined differences between shift-work and sleep quality measures. As police officers often deal with rotating schedules and multi-annual shift-changes, normal sleep patterns are disrupted (Charles et al., 2007; Neylan et al., 2002; Vgontzas et al., 2004; Vila & Kenney, 2002; Violanti & Aron, 1994). As evidenced in the present study, shift-work is related to increases in cortisol expression in police officers. Interestingly, cortisol, as a physiological biomarker for systemic stress, was seen in higher levels in Day-shift workers in comparison to Mid-shift and Night-shift workers. This is the opposite of what was hypothesized. It has been suggested in previous literature that officers may face higher levels of perceived stress when dealing with departmental, administrative conflicts, which could occur more during day-time hours when supervisors are in-office when compared to other shifts (Brown & Campbell, 1990; Burke, 1994;

Evans & Coman, 1993; Franke et al., 2002; Gerson et al., 2002; Liberman et al., 2002; Violanti & Aron, 1995). Day-shifters were also older and had more years of experience on average than mid- or night-shift officers, which may have contributed to their elevated cortisol levels. However, the difference in age between shift-groups was non-significant. Also, the only other traditional marker for cardiovascular health that differed by shift was higher total cholesterol in Day-shifters when compared to Mid-shift officers, which was again, counter to what was initially hypothesized. No other traditional or non-traditional markers for cardiovascular health differed between shifts.

Regarding sleep quality, scores for daytime dysfunction were highest in Night-shift workers. This finding suggests that overnight shifts may play a role in the loss of waking hour concentration, social engagement, energy levels and enthusiasm for accomplishing normal tasks. Shift-work has previously been shown to have implications on circadian rhythm disturbance, sleep dysregulation, and decreased quality and quantity of sleep (Charles et al., 2007; Neylan et al., 2002; Vgontzas et al., 2004; Vila & Kenney, 2002). Daytime dysfunction may be especially prominent for officers who try to readjust from nocturnal to diurnal wake-sleep schedules on days they do not have to work or when trying to take part in normal, daily family or social activities (Monk, 2000; Sack, Blood, & Lewy, 1992). Interestingly, all other *PSQI* indices, including subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbance, use of sleep medications, and global scores for sleep quality were not different between shift-work groups. However, global sleep scores were considered high overall and are distinctive of individuals in the general population with sleep disorders (e.g., excessive sleepiness, or somnolence; Buysse et al., 1989). Sleep disorders with direct causal ties to somnolence are insomnia, obstructive sleep apnea, and narcolepsy (National Sleep Foundation, 2018). This suggests that the majority of officers have higher global sleep quality scores on average, which is indicative of clinically poor sleep quality and potential sleep disorders.

One potential limitation of this research is that data was collected at the beginning of a new year (January-March), when daylight hours are minimal and many officers have just changed to new shift-work schedules. Therefore, sleep quality data may have been impacted by the newly appointed shift-schedules and subsequent changes in officer sleep and wake times. Not all officers have large changes in shift-rotations (e.g., day-shift to night-shift and vice-versa), but given that there are multi-annual changes in working schedules, sleep-wake schedules may consistently be in a state of flux, and thus reflected in universally poor sleep quality.

Future directions for this research could include longitudinal analyses of police officer sleep scores and physiological biomarkers throughout the course of the year. Perhaps then we could deduce within-officer fluctuations in sleep quality and biomarker physiology with multi-annual shift changes. It would be important to understand the differences in both non-traditional and traditional markers of cardiovascular health both at the start of a new shift-time rotation and after acclimatization to a consistent schedule.

In conclusion, the present study has indicated evidence to suggest police officers may have increased levels of certain non-traditional and traditional biomarkers impacted by night shift-work compared to Day- or Mid-shift officers. Also, that certain indices of sleep quality are impacted by night shift-work, which is consistent with previous research regarding positive associations between sleep disruptions and night shift-work (Charles et al., 2007; Neylan et al., 2002; Vgontzas et al., 2004; Vila & Kenney, 2002). Overall, disrupted sleep can impact an officer’s ability to concentrate, make appropriate decisions in high-stress situations, and serve the public to the best of their ability. It is important to find better ways to coordinate rotating shift-schedules so that officers are more supported when and if they have to work overnights. Unfortunately, police officers working night-shifts may be an adverse, but necessary, part of the job to ensure the safety of the community.

CHAPTER

7

SUMMARY AND CONCLUSION

CHAPTER SEVEN: Summary and Conclusion

The purpose of this dissertation was to examine the relationship between occupational stress and cardiovascular health among police officers. Despite a significant amount of research on police officers, the current body of research has either focused on the physiological or psychological implications of the policing occupation, but neither in conjunction with the other. No published study has utilized a multifaceted approach, utilizing physical, physiological and psychological data to understand the complexity of officer health. In comparison with the general population, police officers face earlier mortality, both while in the active work force and post-retirement. Even though officers are a unique population, they still face common societal issues like sleep disturbance, poor diet and exercise habits, elevated BMI and obesity. These occupational and lifestyle variables are present in conjunction with acute and chronic occupational stressors related to work-family balance, long and overtime work hours, shift-work, critical incidents and administrative conflicts. These negative psychosocial factors combined with daily threats to personal and community health and safety create a tumultuous environment for officers to live and work in.

The **first aim** was to examine the effect of occupational and lifestyle variables on ANS and cardiovascular health (Chapter 4). First, the negative impact of shift-work on HRV, VO_{2MAX}, RHR and HRR was examined. It was hypothesized that night-shift officers would express poorer ANS and cardiovascular health indices than day- and middle-shift officers. Unfortunately, there was no clear relationship between shift-groups and measures of ANS function or cardiovascular health. Second, the impact of occupational and lifestyle factors on measures of ANS and cardiovascular health was examined. We hypothesized that officers with increased overtime hours, poor exercise habits, diminished sleep and elevated BMI and body-fat, would exhibit lower HRV, higher RHR, lower VO_{2MAX}, and diminished HRR. The only significant finding was that exercise days per week (positively associated) and body fat percentage (inversely associated), was predictive of VO_{2MAX} outcome values. All other analyses for lifestyle and occupational variables and their influence on HRV indices, RHR and HRR, were non-significant.

The **second aim** was to examine the relationship between psychosocial factors that officers face and physiological markers associated with cardiovascular health (Chapter 5). It was hypothesized that higher psychosocial scores (determined by the *POSS*) for perceived work-stress (perceived inequality and exposure to critical incidents), negative coping strategies, and negative health outcomes (physical, emotional/behavioral and depressive indicators) would be predictive of higher levels of both traditional (blood pressure, total cholesterol, LDL cholesterol, triglycerides and cortisol) and non-traditional markers (CRP, IL-6, IL-1 β, and TNFα) of cardiovascular health. It was hypothesized, that higher administrative support, job satisfaction, and positive coping mechanism scores would be inversely related to lower traditional and non-traditional markers for cardiovascular health. Significant positive relationships were determined between perceived inequality at work and both CRP and TNFα expression. Negative emotional/behavioral indicators positively predicted CRP expression and negative physical health outcomes positively predicted TNFα expression as well. This suggests that inflammatory expression may be impacted by more chronic sources of stress in the work place (e.g., perceived inequality) and poor coping mechanisms (e.g., emotional/behavioral indicators) than from exposure to critical incidents as hypothesized. Despite these findings, other sub-scale outcomes from the *POSS* did not relate to other traditional or non-traditional markers of cardiovascular health.

Aim three was to determine the impact of officer shift-work on both non-traditional and traditional markers of cardiovascular health (Chapter 6). It was hypothesized that night-shift officers would exhibit greater expression of both non-traditional (CRP, IL-6, IL-1β, and TNFα) and traditional markers (BMI, blood pressure, blood lipids, and cortisol) of cardiovascular health when compared to day- or middle-shift officers. The relationship between shift-work and indices of sleep quality determined by the *PSQI* were also examined. It was hypothesized that night-shift officers would have higher scores on the *PSQI* and its sub-scales than day- or mid-shifters. Overall, officers within this study sample had global *PSQI* scores suggestive of poor sleep quality. The only relationship between scores on the *PSQI* and shift-work was evident in higher daytime dysfunction in night-shifters compared to middle-shifters. Interestingly, there was no significant association with Day-Night nor Day-Mid shifts in scores for daytime dysfunction nor any other *PSQI* score. Interestingly, cortisol expression was significantly higher in day-shift officers compared to both Mids and Nights. It was found that day-shift officers had significantly higher total cholesterol than night-shift officers, however relationships been both Days-Mids and Mids-Nights were not present for total cholesterol nor any other traditional markers for cardiovascular health. This is the opposite of what was hypothesized. Given the results from study two (Chapter 5), and in conjunction with previous literature, higher sources of chronic stress are tied to administrative conflicts and thus may be more present during day-shift when higher ranked individuals are present (Brown & Campbell, 1990; Burke, 1994; Evans & Coman, 1993; Franke et al., 2002; Gerson et al., 2002; Liberman et al., 2002; Violanti & Aron, 1995).

This dissertation, contributes to the current body of research on police officers. Even though the findings did not clearly elucidate all relationships between lifestyle and occupational variables, sources of stress officers face, and markers for cardiovascular and ANS health, the combined results from all three studies are indicative that certain lifestyle choices (e.g., exercise, seeking social support) may improve officer health and well-being both physically and mentally. However, certain other aspects of police work (shift-work and chronic, daily stressors) may lead to poor sleep quality and thus higher levels of inflammation. As noted in previous studies, officers have a higher occurrence of negative coping mechanisms in conjunction with a greater incidence of poor mental health. These factors may contribute to overall poorer physical health and autonomic dysregulation that impact disease risk and earlier all-cause mortality. Over time, poor lifestyle choices, unmanaged stressors, and constantly rotating shift schedules may contribute to increased allostatic load, which can contribute to evidenced early, all-cause mortality and instance of sudden cardiac death in police officers.

Although this dissertation addresses many complex facets of officer health, further research is needed to understand specific contributions to higher death rates among officers while on active-duty and post-retirement from the police force. Several other questions regarding police officer heath need to be addressed, and while this is not a comprehensive list, several research questions are outlined below:

1. To what extent does physical fitness play a role in mitigating police officer stressors?
2. To what extent does physical fitness affect traditional and non-traditional markers of cardiovascular and ANS health in police?
3. What other interventions could be employed to mitigate officer stressors?
4. Does the ratio of high-risk calls to routine calls within a year effect the expression of traditional and non-traditional markers for cardiovascular health in police officers?
5. Can 24-hour ambulatory heart rate and HRV monitoring give us better insight into ANS responses to stress? And would on-duty HRV differ from off duty HRV?
6. How would HRR differ on-duty post-critical incident compared to HRR post-maximal exercise? What would this tell us about ANS health?
7. How would traditional and non-traditional marker expression differ within officers before/after multiannual shift-rotation?
8. Would longitudinal monitoring of sleep quality give us insight on the ideal shift-work rotation schedule?
9. How do heart rate, HRR and HRV metrics during police training in high-stress scenarios compare to field-based high-stress scenarios? And how does extensive training impact mental acuity under high-stress scenarios?
10. Would following officers longitudinally post-retirement give us insight into their cardiovascular health profile from active duty to after retirement?

It is important to not only study officer ANS and cardiovascular health, sources of stress and sleep disturbances due to the nature of their jobs, but it is also important to determine how best to approach mitigating these issues. Future solutions in alleviating sources of stress for officers may include better preventive police training programs and debriefing procedures in both mental and physical health sectors. Each department has various ways of handling high-risk and life-threatening scenarios that their officers are exposed to, but there is still a stigma about seeking out and receiving mental/emotional health support. It is critical, especially within the mental health realm, that officers better understand the stress-debriefing resources available to them as well as the importance of utilizing them. Along with utilizing mental health resources, officers should employ other positive coping strategies like exercise and social support. This will not only assist with their physical well-being but also strengthen the relationships around them. When officers are healthier, in both body and mind, they are better able to serve the communities under their protection.

CHAPTER

8

REFERENCES

CHAPTER EIGHT: References

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CHAPTER

9

APPENDICES

CHAPTER NINE: Appendices

Study One

Appendix A
Sample Letter of Recruitment to Police Department Chiefs

UNIVERSITY OF MINNESOTA

Twin Cities Campus

Clinical Exercise Physiology Laboratory
School of Kinesiology
College of Education and Human Development

20 Cooke Hall
1900 University Avenue SE
Minneapolis, MN 55455
(563)210-2543
betke015@umn.edu
www.cehd.umn.edu/kin

November 6, 2015

Chief Name
Department Name
Street Address
City, State, Zip
Phone

Dear Chief Name:

I am writing to ask you and your police department to participate in a research project that will bring our two agencies together in common interest. The Clinical Exercise Physiology Lab at the University of Minnesota conducts several research projects a year and I am excited to present an opportunity for your involvement in a research project looking at cardiovascular health in police officers. I, Morgan Betker, will be leading this project in the interest of using any findings as a part of my Dissertation Research and progress towards the degree requirements for my PhD. I hope to publish my research findings to further the safety of Public Safety Officers in the United States.

In order to participate, officers must be healthy, non-smokers of any age and gender, and be willing to commit up to two hours of time for initial testing at the Clinical Exercise Physiology Lab at the University of Minnesota. The testing will include hydrostatic weighing, VO_{2max} testing, and resting metabolic rate testing. All testing procedures are detailed in the additional documents included in this packet along with consent forms specifying inherent risks and benefits associated with participation. Potential further testing may require participants to come back to the University of Minnesota at a future time and date, however at this time, just one testing session is necessary.

Currently, I need to know whether it would be possible for me to come to your department to give a brief presentation about my research, why it's important and to drum up interest. The initial testing times/dates will be scheduled based on an individual's personal schedule. Directions specific to our lab facility will be given to those interested in participating along with any other pre-testing instructions needed prior to testing.

I appreciate your time and hope you warrant the importance of my study as it could potentially benefit public safety/police officers in the community, state and country. Thank you in advance!

Sincerely,

Morgan Betker, M.S.

Appendix B
Recruitment Email to Police Officers

Hello Officers,

I, Morgan Betker, a graduate student in the School of Kinesiology at the University of Minnesota, am looking for participants for a research study.

The study will evaluate cardiovascular health through a few different, non-invasive tests. Participants will come to the Clinical Exercise Physiology Laboratory at the University of Minnesota for a single, two-hour visit. Upon arriving to our lab facility, participants will take a brief health history survey, to ensure they are healthy enough for participation. Testing will then take place and involve a Resting Metabolic Rate Test, a walking VO_{2max} test and a body composition test. Though there is no compensation for being involved, participants will receive $500 worth of free personal health information and their test results for their own use.

To participate in this study, you must be a healthy, non-smoker, between the ages of 18 and 58. You must have no known cardiovascular abnormalities or prior incidents.

If you are interested in taking part in this study or have questions about the study, please contact Morgan Betker, betke015@umn.edu

Appendix C
Pre-testing Instructions

UNIVERSITY OF MINNESOTA

APPOINTMENT DATE: 05/09/16 TIME: 4:00pm

Dear Officer [Name],

Your exercise test is scheduled at the above time. Please be prompt and prepare for this test as indicated below. Please plan on this appointment lasting between an hour and a half to two hours' time.

In order to ensure the utmost in accuracy we ask that you comply with the following:

Pre-Test Instructions:

- **This test should take place within an hour of waking up after a full period of rest (~8 hours).**
- If you exercise the day before the test, be sure it is of light to moderate intensity and relatively short duration. **You should not exercise within 12 hours of your test.**
- You should not have eaten *within 8 hours* of the test.
- Avoid alcohol, caffeine, and tobacco *within 8 hours* of the test.
- Be sure you are adequately hydrated. Drink plenty of water before the test.
- Wear loose fitting, comfortable clothing and appropriate footwear for exercise. This clothing should be what you would normally wear while running on a summer day.
- For body composition testing you should bring a form-fitting swimsuit or trunks (i.e. spandex shorts). Avoid anything with excess material, as this will interfere with the test's accuracy. Also, please bring a towel

Additional Preparation and Instructions:

Upon your arrival, you will be given a medical history questionnaire and a consent form. Please be sure to have all necessary information available such any pertinent medical information.

If you must cancel or reschedule your test, please do so at least 48 hours in advance. Contact Morgan Betker, betke015@umn.edu or by phone: 563-210-2543 for emergencies.

Pre-test Check-list:

1. No food, caffeine, tobacco or alcohol for the 8 hours prior to testing – water is ok.
2. Swimsuit/compression clothing
3. Towel
4. Athletic clothes
5. Athletic shoes
6. Pertinent medical information in case of emergency

Appendix D
Consent Form

UNIVERSITY OF MINNESOTA
Driven to Discover℠
Human and Sports Performance Laboratory
University of Minnesota – School of Kinesiology
27 University Recreation Center
1906 University Avenue S.E.
Minneapolis, Minnesota 55455
Phone: 612.625.5506

Informed Consent – Public Safety Officer Study
IRB study code: 1505M70201 – 08/23/2015

Testing Procedures

You are being asked to participate in this research study because you are a healthy, non-smoking adult. Before agreeing to participate in this study, it is important that you read and understand the following explanation of the study procedures. The following information describes the purpose, procedures, benefits, inherent risks, and precautions associated with participation in this study. In order to decide whether you wish to take part in this research, you should understand enough about its risks and benefits to be able to make an informed decision. This is known as the consent process. Please ask the study research staff to explain any words or procedures that you don't understand before signing this consent form. Make sure all your questions have been answered to satisfaction prior to signing.

You are invited to participate in a research study investigating how police officers differ from the normal population in levels of cardiovascular fitness, body composition, autonomic functioning, and heart rate variability both at rest and while on duty. You were selected as a possible participant for this study because you are a healthy adult and meet one of the following criteria: (1) you are an active duty police officer or (2) you are an age and sex matched control subject.

This study is being conducted by Morgan Betker, M.S. in the School of Kinesiology, in the Human Sports Performance Lab at the University of Minnesota.

Study Purpose

Police officers are exposed to varying levels of stress during active duty due to various calls they respond to during their shift. Higher levels of stress have been correlated with sleep disruption, high blood pressure, immune system suppression, and sustained sympathetic nervous system activity which can lead to cardiovascular disease. Exercise has been shown to decrease levels of stress, moderate aggressive behavior, lower blood pressure, and lead to better cardiovascular health. Heart rate variability has been used as a means to measure autonomic functioning and stress response, thus the use of a heart rate monitor will be used to measure heart rate variability both at rest, during exercise, and while on duty.

Explanation of Testing Procedures

If you agree to participate in this study, you will be asked to make one, possibly two visits to the University of Minnesota- Twin Cities campus. You will be asked to come to the Human Sports Performance Lab located in the basement of the Recreation Center. Your visit will last approximately two hours. You will be asked to fast for eight hours prior to the test, including abstaining from caffeine, alcohol and tobacco. In addition, subjects will be asked to not exercise vigorously for the 48 hours leading up to the test. Also, participants will need to come to the lab following a good, night's sleep of at least eight hours.

Upon entering the lab, your medical history will first be obtained and reviewed by study staff to ensure that no pre-existing health conditions are present that will exclude you from participation in this study. You will also be asked to take a brief questionnaire about your lifestyle and job duties. Subjects will put a heart rate monitor on with an elastic chest strap, adjusted for fit and comfort. You will then perform a resting metabolic test, wearing a face mask that allows for breath analysis.

Following resting metabolic testing, a body composition test will take place in our underwater weigh tank. The procedure involves the total submersion of your body and head while sitting in a chair that is connected to a scale. While underwater, you will be instructed to exhale as much air out of your lungs as possible, at which point a weight measurement will be taken for 1-2 seconds. Subjects will be given an audible signal to return to the surface. For the sake of consistency, this procedure will be repeated 5-10 times, spaced by at least one minute rest intervals so that each measurement is taken with full subject effort.

After the body composition test, you will perform a VO_{2max} test on a motor-driven treadmill. The exercise intensity will begin at a low level and will be advanced in stages depending on your fitness level. During both the test you will be wearing a facemask and breathing valve that allows for exhaled air to be analyzed. We may stop the test at any time because of signs of fatigue or changes in your heart rate, or symptoms you may experience. It is important for you to realize that you may stop when you wish because of feelings of fatigue, maximal exertion, or any other discomfort.

Field testing will occur outside of the lab and will require subjects to wear a heart rate monitor while on duty. Data consolidation should immediately follow each shift so that accurate recording takes place.

Risks and Discomforts of Study Participation

There exists the possibility of certain changes occurring during the tests. These include abnormal blood pressure, fainting, irregular, fast or slow heart rhythm, and in rare instances, heart attack, stroke, or death. Every effort will be made to minimize these risks by evaluation of preliminary information relating to your health and fitness and by careful observations during testing. Emergency equipment and trained personnel are available to deal with unusual situations that may arise.

Non-compensated Injury

In the event that this research activity results in an injury, treatment will be available, including first aid, emergency treatment and follow-up care as needed. Care for such injuries will be billed in the ordinary manner to you or your insurance company. If you think that you have suffered a research related injury, let the study physicians know right away.

Benefits of Study Participation

These tests can be used to determine your current resting metabolic rate, body composition, maximum exercise capacity, optimal heart rate training intensities, and/or evaluate what types of physical activities you might be able to do with low risk. This knowledge may be used to be used to assess future disease risk and/or moderate lifestyle changes.

Confidentiality

The information that is obtained during exercise testing will be treated as privileged and confidential as described in the Health Insurance Portability and Accountability Act of 1996. The records of this study will be kept private. In any publications or presentations of the current study we will not include any individual identifiers or data that may compromise an individual's privacy. Your record may be reviewed by any or all of the study investigators and research personnel and by departments at the University with appropriate regulatory oversight. No information will be recorded to your medical record. To these extents, confidentiality is not absolute.

Potential Clinically Important Study Findings

The results from the study are for research purposes only and are not intended to provide health care to you. However, if the results should indicate anything of serious potential health risk, you will be notified to determine if self-determined further care is necessary. Further medical follow-up is not a part of this study and therefore, if the results do show something unusual, any medical follow-up cost will be your responsibility or your health insurance carrier.

Responsibilities of the Participant

Information you possess about your health status or previous experiences of heart-related symptoms (e.g., shortness of breath will low-level activity, pain, pressure, tightness, heaviness in the chest, neck, jaw, back, and/or arms) with physical effort may affect the safety of your exercise test. Your prompt reporting of these and any other unusual feelings with effort during the exercise test itself is very important. You are responsible for fully disclosing your medical history, as well as symptoms that may occur during the test. You are also expected to report all medications (including nonprescription) taken recently and, in particular, those taken today, to the testing staff.

Voluntary Nature of the Study

Participation in this study is voluntary. Your decision whether or not to participate in this study will not affect your current or future relations with the University of Minnesota, the School of Kinesiology, the Human Sports Performance Lab, or any other parties associated with the lab. If you decide to participate you are free to withdraw at any time without affecting those relationships.

Inquiries

The researcher conducting this study is Morgan Betker. You may ask any questions you have now, or if you have questions later, you are encouraged to contact them at 563-210-2543 or betke015@umn.edu or the researcher's advisor, Eric Snyder at snyd0180@umn.edu. If you have any questions or concerns regarding the study and would like to talk to someone other than the researcher(s), you are encouraged to contact the Fairview Research Helpline at telephone number 612-672-7692 or toll free at 866-508-6961. You may also contact this office in writing or in person at Fairview Research Administration, 2344 Energy Park Drive, St. Paul, MN 55108

Freedom of Consent

I hereby consent to voluntarily engage in this study to determine my resting metabolic rate, body composition, exercise capacity and state of my cardiovascular health. My permission to take part in this study is given voluntarily. I understand that I am free to stop at any point if I so desire.

I have read this form, and I understand the test procedures that I will perform and the attendant risks and discomforts. Knowing these risks and discomforts, and having had an opportunity to ask questions that have been answered to my satisfaction, I consent to participate in this study.

__________________________________ ________________________

Signature of Patient Date

__________________________________ ________________________

Signature of Person Obtaining Consent Date

Appendix E
Occupational and Lifestyle Survey

UNIVERSITY OF MINNESOTA

Cardiovascular Health and Occupational Stress in Police Officers
Pre-testing occupation/lifestyle survey

1. How many years and months have you served as a police officer? ________
2. What is your normal work shift?

   Day Mid Dog

3. How long is your normal shift (hours)? ________
4. On average, how many hours do you work overtime per week? ________
5. On average, how many hours of sleep do you get per night? ________
6. How many times per week do you exercise? (at least 20-60 minutes continuous physical activity. Ex: Running, swimming, cycling, weight training, kick boxing, sports, walking, etc.) ________

Please indicate what your primary job duties are:

-
-
-
-
-

Appendix F
Bruce Treadmill Protocol

Bruce Treadmill Test

Stage	Time (min)	Speed (mph)	Grade (%)
1	3	2.9	0.0
2	3	1.7	10.0
3	3	2.5	12.0
4	3	3.4	14.0
5	3	4.2	16.0
6	3	5.0	18.0
7	3	5.5	20.0
8	3	6.0	22.0
9	3	6.5	24.0
10	3	7.0	26.0

Studies Two and Three

Appendix E
Letter of Recruitment to Police Drpartment Chiefs

UNIVERSITY OF MINNESOTA

Twin Cities Campus

Clinical Exercise Physiology Laboratory
School of Kinesiology
College of Education and Human Development

20 Cooke Hall
1900 University Avenue SE
Minneapolis, MN 55455
(563)210-2543
betka015@umn.edu
www.cehd.umn.edu/kin

October 10, 2017

Chief Name
Department Name
Street Address
City, State, Zip
Phone

Dear Chief Name:

I am writing to ask you and your police department to participate in a research project that will bring our two agencies together in common interest. I, Morgan Betker, will be leading and staffing a research project through the Clinical Exercise Physiology Laboratory (CEPL) at the University of Minnesota. I am excited to present an opportunity for your voluntary involvement in this research project in conjunction with my dissertation research and progress towards my PhD. My research aims to understand officer occupational stress and the implications on long-term health in the hope of benefitting officers in the community, state and country.

While not looking to impinge upon you or the officers of [NAME] Department's valuable time, the current study may involve extra reporting while on duty. In order to participate, officers must be healthy, non-smokers of any age and gender, and have active status for at least one year prior to testing. Officers must be willing to volunteer up to an hour of time prior to their scheduled shift. The testing will take place in one visit to your department and will include patrol officers taking two surveys, a blood pressure reading and a blood draw for stress biomarkers. Further testing may require participants to a wear heart rate monitor, provided by the CEPL, during their on-duty work, for the duration of 3 normally scheduled shifts. All testing procedures are detailed in the additional documents included in this packet along with the consent form specifying inherent risks and benefits associated with participation. I will also provide more detailed information upon request.

Currently, I would like to determine if you are interested in allowing me access to your officers. The initial testing dates are negotiable, however they would fall somewhere between the first of November through the end of January. I appreciate that this is a time commitment but it is also an important endeavor that could potentially benefit public safety/police officers in the community, state and country. Thank you for your time.

Sincerely,

Morgan R Betker

Morgan R. Betker, M.S.
PhD Candidate, ABD - Exercise Physiology

Appendix F
Recruitment Email and Pre-Testing Instructions to Police Officers

Hello Officers,

My name is Morgan Betker and I'm a graduate student in the School of Kinesiology at the University of Minnesota. I am looking for participants for a research study. You may remember receiving information about an earlier phase of my project back in the winter of 2015-16.

This next phase of my research will evaluate occupational stress and cardiovascular health through a few different measures. First, I want to ensure you that *participation is completely voluntary and every subject's data will be coded with a randomized number to ensure the utmost confidentiality.* Participants will only need to commit about an hour of time before a scheduled shift at your department of work. *You will need to arrive completely fasted from food, caffeine, alcohol and tobacco for 8 hours prior*. Upon arriving, you will take two surveys: a sleep quality index and a police occupational stress survey. After which, I will take a blood pressure reading and draw some blood (about 2 Tbsp.) to analyze for cholesterol, cortisol and a few inflammatory biomarkers.

To participate in this study, you must be an active duty police officer, of any age.

If you are interested in taking part in this study or have questions about the procedures, please contact me, Morgan Betker, directly at betke015@umn.edu.

Appendix G
Consent Form

IRB STUDY: STUDY00001584

Title of Research Study: Occupational Stress and Cardiovascular Health in Police Officers

Researcher Team Contact Information:
For questions about research appointments, the research study, research results, or other concerns, call the study team at:

Researcher Name: Morgan Betker
Researcher Affiliation: University of Minnesota
Phone Number: 563-210-2543
Email Address: betke015@umn.edu

Supported By: This research is supported by the Department of Kinesiology in the College of Education and Human Development at the University of Minnesota.

What is research?
Doctors and researchers are committed to your care and safety. There are important differences between research and treatment plans:

- The goal of research is to learn new things in order to help groups of people in the future. Researchers learn things by following the same plan with a number of participants, so they do not usually make changes to the plan for individual research participants. You, as an individual, may or may not be helped by volunteering for a research study.

Why am I being asked to take part in this research study?
We are asking you to take part in this research study because you are a healthy, non-smoking, active duty patrol police officer.

What should I know about a research study?
- Someone will explain this research study to you.
- Whether or not you take part is up to you.
- You can choose not to take part.
- You can agree to take part and later change your mind.
- Your decision will not be held against you.
- You can ask all the questions you want before you decide.

Why is this research being done?
Police officers are exposed to varying levels of stress during active duty due to various calls they respond to during their shift. Higher levels of stress have been correlated with sleep disruption, high blood pressure, immune system suppression, and sustained sympathetic nervous system activity which can lead to cardiovascular disease. Heart rate variability analysis has been used as a means to measure autonomic functioning and stress response, thus the use of a heart rate monitor will be used to measure heart rate variability while on duty. Blood biomarkers for cholesterol, stress and inflammation have been correlated to cardiovascular health and as predictors of future disease risk and thus, will also be measured during this study. By participating in this study, researchers may begin to understand the mechanisms of issues that

officers face in future disease risk. This can give the researchers valuable information that may be used to promote future interventions to improve officer health, quality of life and longevity.

How long will the research last?
We expect that you will be in this research study for one test visit with potentially up to six follow-up visits for a total of two and a half hours of time commitment all together.

How many people will be studied?
We expect roughly 150 people will be involved in this research study.

What happens if I say "*Yes, I want to be in this research*"?
If you agree to participate in this study, testing procedures will occur on-site at the police department of your employment. You will be asked to fast for eight hours prior to your scheduled testing, including abstaining from caffeine, alcohol and tobacco. In addition, subjects will be asked to not exercise vigorously for the 48 hours leading up to the scheduled appointment.

Testing protocols for the initial visit will last approximately one hour, on-site at the police department where you are employed. Appointments will be arranged at your convenience through March of 2018. First, you will be asked to take two surveys: (1) a police occupational stress survey relating to your sources of work stress, perceived work stress, coping strategies, and clinical stress-outcomes and (2) the Pittsburgh Sleep Quality Index Survey relating to your quality of sleep over the previous month.

Then, the research team will collect a blood pressure reading and a blood sample (in the amount of 30mL or about two table spoons). Blood will be collected for testing traditional plasma markers for cholesterol and stress biomarkers. Blood samples will be stored for up to six months until analysis at a future date when all samples from all participants have been collected. Blood samples will be destroyed after analysis and will not be used for genetic testing.

After which you will be asked to put on a heart rate monitor and record your heart rate for the duration of your shift, for up to three consecutive shifts. The heart rate monitor will be collected immediately by the research team following each shift so that accurate recording of data can take place. Each heart rate monitor transfer including reception, placement and collection should take no more than 15 minutes on either side of each of the three consecutive shifts (totaling a maximum of an hour and a half over three consecutive days).

Call-logs for the previous six months of your active duty will also be collected in order to analyze the percentage of high-risk calls you may respond to in a normal shift. All personal data will be coded with a randomized number to ensure the utmost privacy of your personal information.

What happens if I say "Yes", but I change my mind later?
You can leave the research at any time. Leaving will not be held against you. If you decide to leave the research, contact the investigator so that the investigator can remove your contact information for any future use.

Choosing not to be in this study or to stop being in this study will not result in any penalty to you or loss of benefit to which you are entitled. Meaning, your choice not to be in this study will not negatively affect your right to any present or future medical treatment or your present or future employment.

What are the risks of being in this study? Is there any way being in this study could be bad for me?

Blood draw: There is minimal risk expected with participant blood draws. There may be mild discomfort at the venipuncture including redness, swelling, itching, burning or bruising which may cause the participant mild discomfort. Steps will be taken to adequately mentally prepare you for potential complications from needle entry including these common issues. Sanitized spaces and equipment will be ensured to minimize risk of infection, which is extremely rare.

Blood pressure: There will be minor discomfort due to having a blood pressure cuff inflated briefly on your upper arm for approximately 30 seconds. The degree of risk is minimal; if you are too uncomfortable you may have the cuff deflated prematurely.

Heart Rate Monitoring: There may be mild discomfort from wearing the heart rate monitor chest strap for an extended period of time (duration of your work shift).

Will it cost me anything to participate in this research study?
Taking part in this research study will not lead to any costs to you.

Will being in this study help me in any way?
We cannot promise any benefits to you or others from your taking part in this research. However, possible benefits include knowing and understanding more about your personal health and wellness.

What happens to the information collected for the research?
Efforts will be made to limit the use and disclosure of your personal information, including research study and medical records, to people who have a need to review this information. We cannot promise complete privacy. Organizations that may inspect and copy your information include the IRB and other representatives of this institution, including those that have responsibilities for monitoring or ensuring compliance.

Who do I contact if I have question, concerns or feedback about my experience?
This research has been reviewed and approved by an Institutional Review Board (IRB) within the Human Research Protections Program (HRPP). To share feedback privately with the HRPP about your research experience, call the Research Participants' Advocate Line at 612-625-1650 or go to https://research.umn.edu/units/hrpp/research-participants/questions-concerns. You are encouraged to contact the HRPP if:

- Your questions, concerns, or complaints are not being answered by the research team.
- You cannot reach the research team.
- You want to talk to someone besides the research team.
- You have questions about your rights as a research participant.
- You want to get information or provide input about this research.

Will I have a chance to provide feedback after the study is over?
The Human Research Protection Program may ask you to complete a survey that asks about your experience as a research participant. You do not have to complete the survey if you do not want to. If you do choose to complete the survey, your responses will be anonymous.

If you are not asked to complete a survey, but you would like to share feedback, please contact the study team or the Human Research Protection Program (HRPP). See the "Researcher Contact Information" of this form for study team contact information and "Who do I contact?" of this form for HRPP contact information.

What else do I need to know?
In the event that this research activity results in an injury, treatment will be available, including first aid, emergency treatment and follow-up care as needed. Care for such injuries will be billed in the ordinary manner, to you or your insurance company. If you think that you have suffered a research related injury let the study physicians know right away.

Any results that the research team discover about your personal health will be communicated to you upon request. Should the nature of your results warrant concern about any immediate health hazards, the research team will contact you immediately.

Use of Identifiable Health Information
We are committed to respect your privacy and to keep your personal information confidential. When choosing to take part in this study, you are giving us the permission to use your personal health information that includes health information in your medical records and information that can identify you. For example, personal health information may include your name, address, phone number or social security number. Those persons who get your health information may not be required by Federal privacy laws (such as the Privacy Rule) to protect it. Some of those persons may be able to share your information with others without your separate permission.

The results of this study may also be used for teaching, publications, or for presentation at scientific meetings. Your signature documents your permission to take part in this research. You will be provided a copy of this signed document.

____ _________________
Signature of Participant Date

____
Printed Name of Participant

______________________________________ _________________
Signature of Person Obtaining Consent Date

____
Printed Name of Person Obtaining Consent

Appendix H
Pittsburgh Sleep Quality Index (*PSQI*)

The Pittsburgh Sleep Quality Index (PSQI)

Instructions: The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions.
During the past month,
1. When have you usually gone to bed? ____________________
2. How long (in minutes) has it taken you to fall asleep each night? ____________________
3. When have you usually gotten up in the morning? ____________________
4. How many hours of actual sleep do you get at night? (This may be different than the number of hours you spend in bed) ____________________

5. During the past month, how often have you had trouble sleeping because you…	Not during the past month (0)	Less than once a week (1)	Once or twice a week (2)	Three or more times a week (3)
a. Cannot get to sleep within 30 minutes				
b. Wake up in the middle of the night or early morning				
c. Have to get up to use the bathroom				
d. Cannot breathe comfortably				
e. Cough or snore loudly				
f. Feel too cold				
g. Feel too hot				
h. Have bad dreams				
i. Have pain				
j. Other reason(s), please describe, including how often you have had trouble sleeping because of this reason(s):				
6. During the past month, how often have you taken medicine (prescribed or "over the counter") to help you sleep?				
7. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?				
8. During the past month, how much of a problem has it been for you to keep up enthusiasm to get things done?				
	Very good (0)	Fairly good (1)	Fairly bad (2)	Very bad (3)
9. During the past month, how would you rate your sleep quality overall?				

Component 1	#9 Score	C1_______
Component 2	#2 Score (≤15min=0; 16-30 min=1; 31-60 min=2, >60 min=3) + #5a Score (if sum is equal 0=0; 1-2=1; 3-4=2; 5-6=3)	C2_______
Component 3	#4 Score (>7=0; 6-7=1; 5-6=2; <5=3)	C3_______
Component 4	(total # of hours asleep)/(total # of hours in bed) x 100 >85%=0, 75%-84%=1, 65%-74%=2, <65%=3	C4_______
Component 5	Sum of Scores #5b to #5j (0=0; 1-9=1; 10-18=2; 19-27=3)	C5_______
Component 6	#6 Score	C6_______
Component 7	#7 Score + #8 Score (0=0; 1-2=1; 3-4=2; 5-6=3)	C7_______

Add the seven component scores together ________ **Global PSQI Score** ________

Appendix I
Police Occupational Stress Survey (*POSS*)

Thank you for taking the time to fill out this questionnaire. Since this questionnaire is anonymous, please do not write your name or any other identifying marks on any of the following pages. Take your time and please answer honestly.

I. **Background** Information (please circle where appropriate)

1. What is your sex? Male$_1$ Female$_2$ Prefer not to Answer$_3$
2. Date of birth: ___________________
3. What ethnic group do you belong to?

   African American$_1$ Caucasian$_2$ Hispanic$_3$ Other$_4$

4. Highest level of education completed:

   High School$_1$ Some College$_2$ College$_3$ Graduate School$_4$

5. How many years have you served on the police force? ________________
6. What is your current rank?

   Patrol Officer$_1$ Investigator/Detective$_2$ Sergeant$_3$ Lieutenant or above$_4$

7. Did/do you serve in the military? Yes$_1$ No$_2$
8. Do you routinely have contact with suspects? Yes$_1$ No$_2$
9. What is your marital status?

   Single$_1$ Live-in Partner$_2$ Married$_3$ Divorced/Separated$_4$ Widowed$_5$

10. What is the total number of times you have been married? __________
11. Were you married before you joined the force?

    Yes, to my current spouse$_1$ Yes, to a former spouse$_2$ No$_3$

12. How many children are living in your home now (full or part-time). If none, please circle N/A.

    # of children__________ N/A

13. If you are currently married or living with a significant other, please answer the following questions (if not, check *N/A)

    a. Does your significant other have a job? Yes No N/A
    b. If yes, is he/she a police officer? Yes No N/A
    c. If yes, does he/she work in your same police department? Yes No N/A
    d. What is the highest level of education completed by your spouse/significant other?
       High School$_1$ Some College$_2$ College$_3$ Graduate School$_4$

14. If your spouse/significant other has been married before, please indicate how many times (not including your current marriage)

    # of marriages ___________ *N/A

II. Work Attitudes

Please check the box that best describes how much you agree with the following statements:

	Strongly Agree	Agree	Neither agree/ disagree	Disagree	Strongly Disagree
15. There is good and effective cooperation between units					
16. I can trust my work partner					
17. I view my work as a job, not as a career					
18. There is not enough time at the beginning or end of the day for my chores at home					
19. It is likely I will look for another full-time job outside this department within the next year					
20. Compared to my peers (of the same rank), I find that I am likely to be more criticized for my mistakes					
21. I feel that I am less likely to get chosen for certain assignments because of "who I am" (ex: race, sex/gender, sexual orientation, etc.)					
22. Within the department, sex/gender related jokes are often made in my presence					
23. When I am assertive or question the way things are done, I am considered militant					
24. Promotions in this department are tied to ability and merit					
25. Media reports of alleged police wrong-doing are biased against us/the police force					
26. The administration supports officers who are in trouble					
27. I have had to make split second decisions on the street that could have had serious consequences					
28. The department tends to be more lenient in enforcing rules and regulations for female officers					
29. Some police officers would put their work ahead of everything, including their families					
30. Female officers are held to a higher standard than male officers					

III. Events at Work

If you have ever experienced any of the following, please indicate how much it emotionally impacted you. Please check NA if you have not experienced it.

	Not at all	A little	Very much	N/A
31. Making a violent arrest				
32. Shooting someone in the line of duty				
33. Being the subject of an internal investigation				
34. Responding to a call related to a chemical spill/gas leak				
35. Responding to a bloody crime scene				
36. Personally knowing a victim				
37. Being involved in a hostage situation				
38. Attending a police funeral				
39. Experiencing a needle stick injury or other exposure to blood/body fluids				

Did ANY extremely stressful event you experienced in the past cause you to feel any of the following for 3 months or more?

	Yes	No
40. Cause you to have intrusive or recurrent distressing thoughts, memories, or dreams about the event		
41. Make you avoid things related to the event (ex: thoughts, places, conversations)		
42. Make you feel detached from people and activities that are important to you		

Please check the box that best describes how much you agree with the following statements:

	Strongly Agree	Agree	Neither agree/ disagree	Disagree	Strongly Disagree
43. I can obtain helpful stress debriefing when I need it (ex: not just going to the bar)					
44. I feel that I can rely on support from my family and friends					
45. I feel optimistic or hopeful about the future					
46. I feel like I'm on auto-pilot most of the time					
47. I feel like I need to take control of the people in my life					
48. I feel burned out from my job					
49. I feel like I'm at the end of my rope					
50. I feel like I treat the public as if they were impersonal objects					
51. I have accomplished many worthwhile things in this job					
52. My beliefs about my personal safety, spirituality, outlook, etc. have been changed by my experiences at work.					

IV. Dealing with Stress

When dealing with stressful events at work, how often do you:

	Never	Sometimes	Frequently	Always
53. Draw on your past experiences from a similar situation you have been in before				
54. Stay away from everyone, you want to be alone				
55. Talk with your spouse, relative or friend about the problem				
56. Smoke more to help you relax				
57. Pray for guidance and strength				
58. Make a plan of action and follow it				
59. Exercise regularly to reduce tension				
60. Yell or shout at your spouse/significant other, a family member or professional				
61. Let your feelings out by smashing, breaking or punching things				
62. Hang out more with your fellow officers/friends at a bar				
63. Gamble				
64. Increase your sexual activity				
65. Rely on your faith/religion/spirituality to see you through this rough time				
66. Try to act as if nothing is bothering you				

During the past 6 months…

	Yes	No	N/A (don't drink)
67. Did you ever worry or feel guilty about your alcohol consumption?			
68. Did you ever drink more than you planned?			
69. Did you have periods when you could not remember what happened when you were drinking?			

V. Health Section

Do you suffer from any of the following health problems? Please check all that apply.

	Yes	No
70. Migraines		
71. Chronic low back pain		
72. Liver disease		
73. Heart disease		
74. Chronic insomnia (unable to fall asleep quickly/stay asleep)		
75. Diabetes		
76. High Blood Pressure		
77. Foot problems		
78. Reproductive problems		

	Yes	No
79. Do you currently use tobacco of any kind?		
80. Have you had any serious injury (ex: car accident, surgery, etc) in the past 6 months?		

In the past 6 months, how often did you have (check all that apply):

	Never	Sometimes	Frequently	Always
81. Pains or pounding in your heart/chest				
82. Faintness or dizziness				
83. Loss of sexual interest or pleasure				
84. Feelings of low energy or fatigue				
85. Thoughts of suicide				
86. Feelings of being trapped or caught				
87. Headaches or pressure in your head				
88. Blaming yourself for things				
89. Feeling blue				
90. Nausea, upset stomach, or stomach pains				
91. Suddenly scared for no reason				
92. Feeling no interest in things				
93. Trouble getting your breath				
94. A lump in your throat				
95. Feeling hopeless about the future				
96. Spells of terror or panic				
97. Feeling so restless you couldn't sit still				
98. Crying easily				
99. Feeling that something bad was going to happen to you at work				

How often are the following statements true?

	Never	Sometimes	Frequently	Always
100. I feel tired at work even with adequate sleep				
101. I am moody, irritable or impatient over small problems				
102. I want to withdraw from the constant demands on my time and energy from work				
103. I feel negative, futile or depressed about work				
104. I think that I am not as efficient at work as I should be				
105. I feel physically, emotionally, and spiritually depleted				
106. My resistance to illness is lowered because of my work				
107. I feel uncaring about the problems and needs of the public when I am at work				
108. I have difficulty concentrating on my job				
109. When I ask myself why I get up and go to work, the only answer that occurs to me is "*I have to*"				

VI. Behaviors

Have you ever gotten out of control and been physical (ex. pushing, shoving, grabbing) with:

	Yes	No
110. A fellow officer		
111. Your spouse/significant other		
112. Your child(ren)		
113. Your pet(s)		

Have these people ever gotten physical with you?

	Yes	No
114. A fellow officer		
115. Your spouse/significant other		
116. Suspects or civilians		
117. Your parents (when you were a child)		
118. Did your parents ever get physical with each other?		

VII. Home Issues

Please check the box that best describes how much you agree with the following statements:

	Strongly Agree	Agree	Neither agree/ disagree	Disagree	Strongly Disagree	NA
119. I often get home too physically and emotionally exhausted to deal with my spouse/significant other						
120. I encourage my spouse/significant other to spend time with their family and friends						

	Strongly Agree	Agree	Neither agree/ disagree	Disagree	Strongly Disagree
121. I catch myself treating my family the way I treat my suspects					
122. At home, I can never shake off the feeling of being a police officer					
123. I expect to have the final say on how things are done in my household					
124. It is okay for a person to get physical (ex: shoving, grabbing, smacking) with his or her spouse/significant other if they've been unfaithful					
125. Getting physical once in a while can help maintain a marriage/relationship					
126. There is no excuse for people getting physical with their spouse/significant other					

Thank you for your time and effort. Your input will give us valuable insight that may identify common areas of stress within your life and occupation in the attempt to make your work environment better for the future. If you have any questions, comments or need more information, please email me at betke015@umn.edu – Morgan Betker